8.3 The Anelex Line Printer.

General

The standard installation comprises an Anelex High Speed Printer series 4-1000 with

1. a print barrel rotating at 1000 revolutions per minute,

2. a row of soleniod driver hammers,

3. a code wheel which is locked to the print barrel to determine the time for triggering a hammer for the appropriate character to be printed.

4. a mechanism for automatically feeding inked ribbon and advancing paper through the printer between the hammers and the print barrel.

5. a Format Control which works in conjunction with the paper feed mechanism to automatically vary the vertical spacing of printed lines. It consists of a brush-read paper tape reader which reads sprocket fed paper tape with up to eight channels.

6. mechanisms for manually adjusting the position of the printed line, the paper tension, and the print quality, as well as the phasing of the hammer triggers with respect to the instantaneous barrel position.

7. transistorised pulse shaping, gating and amplifying circuits on printed boards.

8. solid state electronics for driving the hammers,

9. power supplies,

10. core store and associated electronics to generate the control signals from peripheral to computer. The core store holds a complete line of 120 characters.

The printer has 120 print positions spaced 0.1 inches apart along the barrel. Although the barrel speed is normally 1000 revolutions per minute a control can reduce this to 667 r.p.m. when improved printing quality is required.

The traction mechanisms for feeding the paper can be varied in position laterally so that widths of paper from 4 to 19 inches can be used. No indication is given to the computer when the width of paper being used is too narrow to accommodate 120 characters on a line and hence it is the responsibility of the operator to ensure that the required width of paper is loaded and also that the paper is loaded so that the Paper Low detection light is intercepted by the paper.

Each hammer module has two adjustments, one for flight time to control the printing level along the line and the other for penetration to control the thickness of print for the character position.

A single line feed takes 16 m.s. and each additional line feed takes a further 6.67 milliseconds.

The printing of the top copy is by inked silk ribbon with a life of approx. 3/4 -1 million lines. Up to five copies, plus the top copy, can be obtained using one-time carbon. Changing of the ribbon takes about three minutes.

There are 64 different characters on the barrel in each print position. It is possible to print at 1000 lines per minute if only 48 consecutive characters on the circumference of the barrel are being used. A single line feed can be completed in the time for a quarter of a revolution of the barrel and hence a line of up to 48 consecutive characters may be printed and a single line feed given every barrel revolution. If more than 48 consecutive characters are being used the printing

8.3 Continued

speed is reduced and if all 64 characters are being used 4 lines may be printed every 5 revolutions of the print barrel i.e. 800 lines per minute.

The required logic to detect the presence of characters in the different positions round the barrel for a particular line is contained in the printer.

All paper handling equipment is integral with the printer. The paper feed is controlled by a pair of tractors, one above and one below the print head and tensioning of the paper can be carried out during printing. The form can be raised or lowered by about 3 line spaces during printing.

Lateral tensioning and positioning can be carried out by moving the appropriate tractors while the printer is not operating.

Controls and Indicators

a) Mechanical Controls

These are situated on the front of the print mechanism and are as follows:

1. Penetration

This controls the depth of print to allow for the thickness of the paper and the number of copies being printed.

2. Positioning

While printing is in progress the form can be lined up by shifting it up or down by a maximum of three line spaces.

3. Tensioning

This controls the lateral tensioning of the paper and can only be used while the printer is stopped.

4. Phasing

This controls the timing of the trigger to the hammer drivers relative to the instantaneous barrel position to allow for different thicknesses of paper, or multiple copies, and the two barrel speeds.

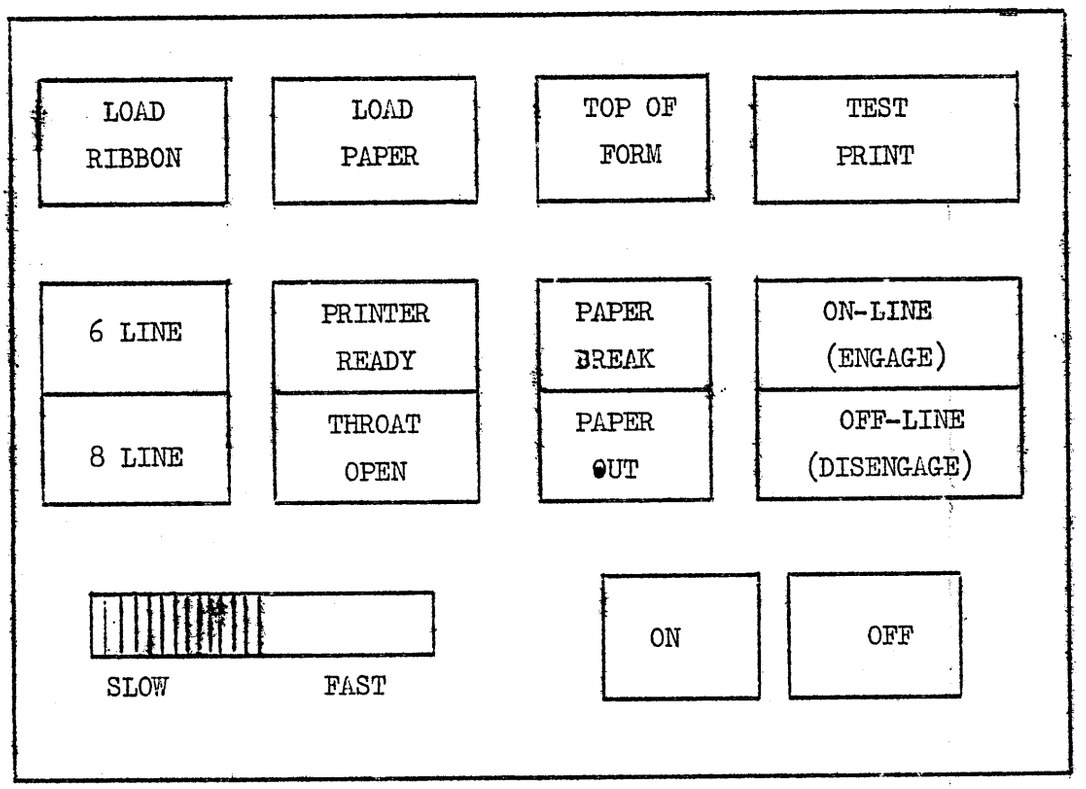
5. Barrel Speed

This is a switch to enable either full or 2/3 full speed (Fast or Slow) for the print barrel to be selected. It is situated on the control panel illustrated on the diagram below.

b) Electronic Controls

The control panel is situated on the front of the printer and is as follows:

8.3 Continued



1) ON/OFF

These are two push button switches and indicators at the bottom right of the control panel which indicate whether the electronics of the printer are switched on or off. The OFF button is lit Red when power is available to the printer but the electronics are switched off; in this case the remainder of the indicators are unlit. The ON button is lit Green when the power to the electronics is on and in this case the OFF button is unlit.

2) ON-LINE/OFF-LINE (ENGAGE/DISENGAGE)

This is a double-action push button and indicator which corresponds to the Engage/Disengage button on the other equipments and for the sake of consistency it will in future paragraphs be refered to as the Engage/Disengage button. Only one half of this button is lit at one time, the upper half being lit Green when the printer is engaged (On-Line) and the lower half being lit Red when the printer is disengaged (Off-Line). The printer is always in the disengaged state when initially switched on. It is only possible to engage the printer when it is in full working order i.e. no fault condition exists and some paper is in the feed mechanism.

3) PAPER BREAK/PAPER OUT

This is a double indicator which is normally unlit but the top or bottom half is lit white when appropriate. 'The Paper Out" is detected by a reflected light device below the feeding mechanism and gives a warning to the computer but does not set the Stop digit in the V-store. This therefore allows the output to be discontinued at some convenient point. The "Paper Break" is detected near the print head by microswitch and in addition to giving the Paper Warning signal sends a Stop signal.

4) PRINTER READY/THROAT OPEN

This is a double indicator, the top half of which is lit Green when the printer is in an operational condition; the lower half is lit white when the cover over the print mechanism is open.

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8.3 Continued

5) 6 LINE/8 LINE

This has no relevance on the Atlas Anelex.

6) TEST PRINT

This button is normally lit Yellow and is used for testing the printer off-line. It is used in conjunction with six switches which are situated at the back of the printer (and inside the outer covering) and which enables any one of the 64 available print characters to be selected. If this button is pressed when the printer is Disengaged the selected character is printed continuously in all 120 positions across the paper. The printing continues until the first Top of Form indication is detected after the button is released. A further feed of one form takes place, without printing, before the printer stops. Pressing the button when the printer is Engaged has no effect.

7) TOP OF FORM

This button is normally lit Yellow and when pressed a one is "OR"-ed into the Disengaged digit in the V-store making the printer appear to be temporarily disengaged. Paper is fed to the next "top of form" digit specified in Channel 1 of the paper tape used for format control. If there is no top of form digit on the paper tape the paper is fed continuously.

No control signals are normally sent to the printer when it is disengaged. If however the End of Line and Vertical Format signals are sent after the run-out button has been pressed and before the Top of Form feed is finished the contents of the buffer are printed.

If the button is pressed when the printer is engaged the buffer is not cleared but a further Print Look At Me signal is sent at the completion of the paper feeding.

8) LOAD PAPER and LOAD RIBBON

The Load Paper button is pressed before loading paper to allow the top of a form to be lined up with a predetermined mark on the lower module cover or on the left hand tractor. It is used in conjunction with the Load Paper digit in the paper feed loop.

The Load Ribbon button is used to facilitate loading the ink ribbon by filling the inner ink ribbon mandril with ribbon until all the ribbon is on that mandril.

These two buttons and indicators are normally lit Yellow and are only effective when the printer is disengaged.

The V-store Digits

Peripheral V-store Type 4. (*60041000)

Line	Digits		
0	36	W1	Clear Core Store
	35	W1	End of Line
	34	W1	Information Strobe
	33-28	W1	Information
	27	RW1	Read: Disabled Write: Start

8.3 Continued

Line	Digits		
0	26	RW1	Read: Paper Warning Write: Put Out Look At Me's
	25	RW1	Read: Stopped Write: Stop
	24	RW1	Read: Disengaged Write: Disengage

Type 14. (*60043430)

Line	Digit		
3	24	R	Overflow Look At Me
	28	R	Print Look At Me

The pin allocations for the above signals are given in Section 8.1.3.

Signals to and from the Computer

To engage the printer it is necessary to press the Engage button; it is not possible for the printer to be engaged directly by the computer. Pressing the Engage button resets the Disengaged digit in the V-store (digit 24) to read as zero provided that neither a Disabled nor a Paper Out signal is being given by the printer. If either of these signals is present pressing the Engage button has no effect. The Disengaged digit is examined by the peripheral supervisor during every "One Second Interrupt" and the printer may be started if it is engaged.

The printer's buffer store is not automatically cleared when the Engage button is pressed and hence it is necessary for the computer to send a "Clear Core Store" signal (digit 36) before any information is transferred. The buffer is subsequently cleared automatically whenever a line of information is printed.

The printer may be disengaged either (a) by the computer writing a one to the Disengaged digit or (b) by an operator pressing the Disengaged button or (c) (temporarily) by an operator pressing the Top of Form button.

After the Start signal has been sent from the computer (digit 27), a Print Look At Me signal is sent when the printer is fully operational. This indicates that the transfer of information from the computer to the printer's core store (via the V-store, digits 33-28) can take place. The characters are sent one at a time and may not be sent more frequently than one every 16 μ-secs. There is no maximum time during which the characters for a line are sent to the V-store and hence the Put Out Look At Me (digit 26) must be sent as soon as the computer has recognised the Print interrupt. This thus enables the computer to deal with other interrupts if necessary during the transfer of information. Simultaneously with sending each six-bit character to digits 33-28 a further bit must be written to the Information Strobe digit (digit 34). This enables the printer to recognise information and control signals.

When a complete line of characters has been transferred (this might be any number of characters up to a maximum of 120) an "End of Line" signal (digit 35) is given together with, or followed by, a Vertical Format character. The latter is written to the Information digits and a one is also written to the Information Strobe digit. After the line has been printed and whilst

8.3 Continued

the specified paper feeding is taking place a further Print Look At Me signal is sent to the computer, thus enabling further information to be put in the core store during the paper feeding operation. There is a delay of apprcximately 8 m.s. after sending the Vertical Format character before the next Print Look At Me is given. This is to enable the information in the buffer core store to be transferred to the electronics. No further Look At Me signal is sent if the Start/Stop flip flop has been set to Stopped. This may have been done either (1) by the computer writing a one to the Stop digit (digit 25) because no further information is available for printing or (2) by the printer being disengaged or (3) because a Disabled or Paper Out Signal has been given by the printer.

During the transfer of information the buffer automatically scans the characters and printing starts with the first available appropriate character. When all the characters have been printed the line feeding commences and a further Print Look At Me signal is sent to the computer. This Print Look At Me is given about 8 m.secs. after the printer receives the Vertical Format character. The transfer of information for the next line thus takes place during the line feeding and further printing may start with the first available character after the line feed has finished.

A Print Look At Me is sent to the computer only if all the following conditions are satisfied:

(a) the system is "Able" i.e. the printer is switched on, all fuses are intact and paper is loaded.

(b) the printer is engaged.

(c) the system has received a "Start" signal from the computer.
Only when conditions (a) and (b) above are fulfilled can the computer switch the system into the "Started" condition.

(d) the system is not "Print busy".
The printer starts the printing cycle immediately it receives an "End of Line" or a "Clear Core Store" signal from the computer. It remains "print busy" in the former case until the core store has transferred its contents into the mechanics and has emptied itself which can take a maximum of 60 m.secs. If a "Vertical Format" character (essentially an Information Strobe) is not received within this time the printer remains in the print busy state until one is received. After a "Clear Core Store" signal the printer is "print busy" until the core store has been reset to zero which takes about 720 μ.secs.

(e) the system is not "Vertical Format busy".
The paper feed cycle commences immediately a Vertical Format character is received and the system remains "Vertical Format busy" until the printer receives the appropriate stop signal from the paper feed mechanism. The paper feeding does not commence whilst the system is "print busy" and it takes about 7 m.secs. to come to a halt after the stop signal. This latter period is masked on a non-zero vertical format command by an 8 m.secs. "Print Interlock" which prevents the beginning of the next print cycle until this time has elasped. (This is also the period in which an information transfer for a line of print from the computer must be completed to obtain full speed working).

The total time of the electrical Feed Paper command takes about 8 m.secs. (between 6.2 and 8.2) for one line plus 6.67 m.secs. for each line succeeding the first i.e. a paper feed rate of 150 lines per second. There is a "Vertical Format interlock" of 20 m.secs. at the end of the "Vertical Format busy" state which prevents further paper feeding being initiated within this period.

8.3 Continued

The Print Look At Me is thus generated

(i) within 2 μ.sec. if conditions a, b, d and e are all satisfied and the printer receives a "Start" signal.

(ii) 720 μ.secs. after receiving a "Clear Core Store" signal.

(iii) between 720 μ.secs. and 60 m.secs. (Print cycle time) plus 8+(n-1) 6.67 m.secs. (Line feed time) after receiving an "End of Line" signal where n is the (non-zero) number of lines contained in the Vertical Format character sent with or following the End of Line signal. The minimum time of 720 μ.secs. is obtained for the "printing" of all spaces and zero line feed. The maximum is 60 m.secs. (whenever all the 64 different characters on the barrel are to be printed) plus the maximum number of lines to be fed which is the number of lines on a complete form (6 lines to the inch). In all other cases it is difficult to predict the print cycle time as it not only depends on the number of different characters, and their distribution round the print barrel, in the line to be printed but also on the exact location of the print barrel at the time the print cycle starts.

If the printer is disengaged by push-button during a transfer of information to its core store, the transfer is continued until completed. Before an "End of Line" signal is given the fixed store program examines the Disengaged digit and only sends the signal if the printer is Engaged. Otherwise the information is retained in the core store buffer until the printer is re-engaged. Disengaging the printer does not inhibit any mechanical actions. Hence if the printer is disengaged in the time between the fixed store program reading the Disengaged digit as zero and sending the End of Line signal the line feeding still takes place.

If a fault condition is detected by the fixed store program during the transfer of a line of information the characters already copied to the core store can be cleared by writing a one to the "Clear Core Store" digit. A further Look At Me signal is given by the printer when the core store has been cleared and the transfer can be restarted.

A Disabled signal is given by the printer (digit 27) and the Stop/Start flip-flop set to Stopped if a failure (fuses blown or D.C. not ready) is detected. The printer is disengaged by the fixed store program at the next "one second interrupt" and the digit is reset automatically when the fault has been corrected. The printer cannot be re-engaged whilst the fault condition exists.

The Paper Warning signal is given (digit 26) if the Paper Low light detects that there is no paper in the bottom container or if the Throat Cover over the print head is open but the printer is not stopped in this case. This digit is reset automatically when more paper is loaded.

This digit is also set, and the printer is stopped, if the Paper Out microswitch operates because the paper is torn. The fixed store program disengages the printer at the next one second interrupt. The digit is automatically reset when more paper is loaded. The printer cannot be re-engaged before the Paper Out condition is corrected.

An "Overflow Look At Me" signal is given if the computer sends more than 120 characters for a line. This interrupt occurs even if the printer is stopped or paper feeding and is given within about 8 μ.secs. of the 121st character having been sent to the V-store. On entering the Overflow Interrupt routine the fixed store program writes an End of Line Digit and

8.3 Continued

a Vertical Format character to the V-store thus initiating the printing of the first 120 characters which were sent to the core store for that line. The fixed store program can then send this 121st character to form the first character of a new line on the next Print Look At Me interrupt. The Overflow Look At Me is reset by writing a one to digit 26 as for the Print Look At Me.

If the printer is disengaged when the Overflow Look At Me is set the printer becomes busy until either a Vertical Format character (i.e. an Infromation Strobe) or a Clear Core Store signal is received or the Test Print button is pressed. The Look At Me is automatically reset.

Paper Feeding.

The paper feeding may be specified by using the Vertical Format character in either of two ways

(i) in conjunction with a paper tape loop or

(ii) by specifying in binary the number of lines required to be thrown.

In the first case the three most significant digits of the vertical format character must all be ones. The three least significant digits specify in binary the channel of the vertical format control which is required. This format control is situated in the printer and consists of a brush-read tape reader which, for Atlas, reads standard 7-channel paper tape. The loop of paper tape has the same number of characters as the form under the print head has lines and for every line feed which takes place on the printer the paper tape loop is advanced by one character. When one of the channels of the paper tape loop is specified by the three least significant digits of the vertical format character the form is thrown until a hole is sensed in that channel of the paper tape, or until the next top of form digit. One channel is reserved for the "top of format" signal (required by the Paper Run Out button) and this is always channel 1 i.e. character 111001. In other applications of the printer where eight channel paper tape is used the character 111111 is used to specify channel 7. For Atlas, using seven channel tape this character is not applicable.

The layout characters are thus

111000	channel 0	load paper
111001	channel 1	top of form
111010	channel 2	
111011	channel 3	
111100	channel 4	
111101	channel 5	
111110	channel 6	
111111	not applicable	

The second method of specifying paper feeding is where one or more of the three most significant digits of the vertical format character is a zero. In this case the number of line feeds is given by the binary interpretation of this character. The number of lines which can be fed by this means varies from 0 to 55, i.e.

000000	no line feed
000001	single line feed

8.3 Continued

000010	two line feeds
.	.
.	.
.	.
110111	55 line feeds

The character 000000 suppresses line spacing to allow overprinting.
The line feed is terminated if a top of form digit is detected in the paper feed loop before the specified number of line feeds has been completed.

The first information character written to the core store after a vertical format character is printed in column one irrespective of where the printing for the last line finished.

Details of Signals

The signals to the printer from the computer conform to the following specification:

a) two wire inputs for use with sub-miniature co-axial cable of 50 ohm impedance and approximately 30 pF per foot.

b) Levels:

logic 1	-1 volts minimum
	-1.5 volts maximum
logic 2	+1.5 volts minimum
	+2 volts maximum

c) pulse width a minimum of 2 μ secs at the peripheral end with edges at 4.5 volts / μ sec. measured at 10 per cent and 90 per cent of peak to peak amplitude in both directions.

d) maximum D.C. loading 1 m. A at the peripheral end.

Six lines carry the 6 bit character transfers at a rate not exceeding 62.5 Kc/s.

The signals from the printer to the computer conform to the following specification:

a) two wire outputs for use with sub-miniature co-axial cable of 50 ohm impedance and approximately 30 pF per foot.

b) Levels:

logic 1	-2	minimum
	-4.5	maximum
logic 0	+2	minimum
	+4.5	maximum

c) edge speeds are 4.5 volts per μ sec. when measured at 10 per cent and 90 per cent of the peak to peak amplitude in both directions when loaded with 3000 pf.

d) the maximum current to be supplied to the cable is 10 m.A.

e) the reference level 0 volts must be floating, i.e. insulated from mains ground.

8.3 Continued

Installation Details

The approximate dimensions of the control pedestal and printer unit are:

Width 58 inches

Depth 30.5 inches

Height 55.25 inches

Total weight is approximately 1900 lbs.

The power supply is single phase A.C. at 50 c.p.s. and 240 volts ± 15 per cent. The power consumption of the printer pedestal is 2.0 KVA approximately.

8.3 Continued

Character Lay-out

The following characters are on the wheel in the sequence given:

Sequence	Internal code (Octal)	Octal Code sent to printer	Character	Sequence	Internal code (Octal)	Octal Code sent to printer	Character
-	01-I	40	Space	32	52-I	00	J
1	20-I	01	0 Zero	33	53-I	41	K
2	34-0	02	1/2	34	54-I	42	L
3	21-I	43	1 One	35	55-I	03	M
4	36-I	04	- Minus	36	56-I	44	N
5	22-I	45	2	37	57-I	05	O
6	35-I	46	+	38	60-I	06	P
7	23-I	07	3	39	61-I	47	Q
	37-I	10	• Point	40	62-I	50	R
	24-I	51	4	41	63-I	11	S
10	03-0	52	£ Pound Sterling	42	64-I	12	T
11	25-I	13	5	43	65-I	53	U
12	15-I	54	&	44	66-I	14	V
13	26-I	15	6	45	67-I	55	W
14	10-I	16	(	46	70-I	56	X
15	27-I	57	7	47	71-I	17	Y
16	11-I	20	)	48	72-I	60	Z
17	30-I	61	8	49	17-0	21	:
18	16-I	62	* Asterisk	50	40-I	22	' Apostrophe
19	31-I	23	9	51	21-0	63	[
	17-I	64	/	52	22-0	24	]
21	35-0	25	10 Ten	53	32-I	65	<
22	36-0	26	11 Eleven	54	33-I	66	>
23	41-I	67	A	55	34-I	27	= Equals
24	42-I	70	B	56	26-0	30	_ Underline
25	43-I	31	C	57	27-0	71	| Vertical Line
26	44-I	32	D	58	14-I	72	?
27	45-I	73	E	59	12-I	33	,
28	46-I	34	F	60	30-0	74	2 Super script 2
29	47-I	75	G	61	13-I	35	π Pi
30	50-I	76	H	62	32-0	36	α Alpha
31	51-I	37	I	63	33-0	77	β Beta

8.4 The I.C.T. Card Punch

General

This equipment comprises an I.C.T. type 582 Card Punch and associated electronics. The punch handles 80-column cards at the rate of 100 cards per minute. Cards are fed broadside on, face down, with the Y edge leading, thus punching one row at a time. The card track comprises magazine, punching station, check reading station and stacker. The card capacities of the magazine and stacker are approximately 700 and 800 cards respectively.

Reading brushes are placed one card cycle after the punch knives. It takes four card cycles for a card to pass from the magazine to the stacker, the sequence being.

1st cycle, the leading edge of the card approaches the punch knives.
2nd cycle, the card passes through the punch station.
3rd cycle, the card passes under the read brushes.
4th cycle, the card passes into the stacker.

On a "Start" (or "Feed Card") order a card is always fed to the punch knives. If there is no card already approaching the punch knives two cycles are automatically carried out and two cards taken from the magazine. The first card is punched and the second card left with its leading edge approaching the punch knives. Cards are fed continuously, one per card cycle, until a Stop signal is given.

A plugboard is provided which allows any of 80 computer channels to be connected to any of the 80 punch magnets. Not more than two magnets may be driven from one channel. A similar distribution of the 80 check-reading brushes is possible. It is not anticapted that this facility will be used on Atlas except for maintenance purposes.

Provision is made for off-setting a card in the stacker by about 3/8 inch. Thus if the information read at the checking station does not agree with the information that should have been punched the fixed store program gives an "Offset" order and punches the information on a second card. The operator removes all off-set cards when unloading the stacker.

No limitation is placed on the number of holes that can be punched in a card.

The punch may be used off-line as a gang punch, by changing the plugboard and switching to local control. This is intended as a maintenance rather than an operational facility. For this reason the plugboard also carries the twelve outlets for an emitter, each corresponding to one row of a card.

8.4 Continued

The V-store Digits

Type 9

line	digits		
0 (*60042200)	47-40	RW10	Information. One digit of each of columns 8-1 respectively where column 1 is that first in the card punch. Read: Brush Information Write: Punch Information
	39	RW1	Read: Card Levels Write: Put Out Brush Look At Me
	38	RW1	Read: Card Wreck Write: Reset Overdue
	37	R	Overdue
	29	W1	Do not Offset
	28	W1	Put Out End of Card Look At Me
	27	W1	Start
	26	W1	Put Out Punch Look At Me
	25	RW1	Read: Stopped Write: Stop
	24	RW1	Read: Disengaged Write: Disengage
4 (*60042240)	47-24	RW10	Information (see line 0). One digit of each of columns 32-9 respectively
8 (*60042300)	47-24	RW10	Information (see line 0). One digit of each of columns 56-33 respectively
12 (*60042340)	47-24	RW10	Information (see line 0). One digit of each of columns 80-57 respectively

Type 14 (*60043460)

line	digit		
6	24	R	End of Card Look At Me
	26	R	Punch Look At Me
	28	R	Brush Look At Me

ontrols and Indicators

a) Engage Push-button and Indicator

It is only possible for the punch to accept information from the computer if it has been Engaged and it can only be Engaged by an operator pressing the Engage push-button. It is impossible to Engage unless the punch is able to deal with information from the computer, e.g. unless there are cards in the magazine, there is no card wreck, the receiver is not full, the fuses are intact etc.

Combined with the push-button there is an indicator which lights Green when the equipment is Engaged and White when the punch is Disengaged.

b) Disengage Push-button and Indicator

The punch may be Disengaged by instruction from the computer, or by an operator pressing the Disengage push-button.

When the button is pressed a Disengaged signal is sent immediately to the peripheral co-ordinator setting the appropriate V-store digit. The equipment is Disengaged immediately if it is not currently punching (or check-reading) otherwise it is disengaged automatically at the end of the current cycle.

8.4 Continued

Combined with the push-button is an indicator which lights Red when the equipment is Disengaged and White when the punch is Engaged.

c) Start Push-button and Indicator

When, and only when, the equipment is Disengaged is it under local control. Pressing the start button then causes the punch to cycle, feeding cards if there are any.

In this condition the equipment may be used as a gang-punch, provided a suitable plugboard is used, or the facility may simply be used to clear the card tracks.

Combined with the push-button is an indicator, coloured White, which lights while the machine is performing a cycle whether under computer or local control.

d) Stop Push-button

Pressing this stops the punch cycling only if it is under local control, i.e. Disengaged. If the punch is Disengaged and cycling it is only possible to Engage it after the Stop button has been pressed.

e) Power On/Off Switch and Indicator

There is a power on/off switch on the punch. When the switch is on the Power On indicator, coloured Green, lights up.

f) Magazine Empty Indicator

g) Stacker Full Indicator

h) Card Wreck Indicator

These are indications that the punch is disabled until it receives attention. All are coloured Yellow.

Signals between the Computer and the Punch

During normal operation three separate causes of interruption may occur. These are

i) when a card is ready to have a row punched
ii) when a row of the card has been read at the check-read station
iii) when an End of Card signal is received

The digits referred to below are the digits of line 0 of the Card Punch V-store.

a) Disengage (digit 24)

This digit is read as a one when the card reader is Disengaged, and read as a zero when it is Engaged. It is reset to zero only by the operator pressing the Engage button on the card reader.

It is set to one either when the computer writes a one to it or when the Disengage button is pressed. In this latter case the punch is not stopped and disengaged until after the current cycle has been completed although the Disengaged digit in the V-store is set immediately. The punch must be Engaged before any cards can be fed.

8.4 Continued

b) Start (digit 27)

Writing a one to the Start digit initiates the feeding of cards. This signal starts the motor and when it has run up to a stable speed, taking up to 800 m.sec., feeds a card to the punch knives. If there is no card in the track waiting to pass the punching station the machine automatically performs a second cycle. Cards are thenfed continously until a Stop singal is given either from the computer or from the punch itself. This latter may be either due to a fault indication or because the punch has been disengaged.

c) Stop (digit 25)

Writing a one to the Stop digit inhibits all further Look At Me's and prevents card feeding. A one must be written to the Stop digit within 12 m.secs. of the End of Card Look At Me otherwise a further card is fed. At the end of punching a pack of cards two blank cards are in the card track, one about to pass under the check read station and the other about to pass under the punch knives.

The Stop signal may also be given by the punch if either

(i) the Disengage button is pressed or
(ii) either Operator or Engineer attention is required.

In these cases the Stop digit is set and the punch stopped 2 m.secs. after the next End of Card signal. The motor is automatically run down if the Stop digit remains set for more than 400 m.secs.

For mechanical reasons it is not possible to re-engage the clutch whilst it is in the process of disengaging. This effectively means that the punch cannot be started again between 10 m.secs. and 1 sec. after a Stop signal has been given to it. A delay is therefore incorporated to hold-off any Start signal sent during this period.

d) Put Out Punch Row Look At Me (digit 26)

An automatic interrupt occurs whenever the card is ready to have information punched on to a row. These signals occur every 43 m.secs. and are present for about 35 m.secs. of this time. If the signal is not put out in this time an Overdue digit is set, the Stop/Start flip-flop set to stopped and no further interrupts are given.

e) Put Out End of Card Look At Me (digit 28)

The End of Card interrupt occurs simultaneously with the last row interrupt from the Check Read (Brush), station, but has a lower priority than the Brush interrupt. If no card is in this station it occurs at a similar time in the cycle for the card at the punch station.

The fixed store program sets the Do Not Off-set digit if the card just checked has been punched and checked correctly. The Stop signal is also given at this time if it is required to terminate the feeding of the cards. In order to check the last card in a pack it is thus necessary to have an extra card passing under the punch knives whilst this last card is being checked. No holes are punched in this extra card.

f) Put Out Brush Look At Me (digit 39)

The Brush Look At Me interrupt for the card at the reading station occurs 40 m.secs. after the Punch Row interrupt for the corresponding row of the card at the punch station. If the information has not been read and the Put Out Brush Look At Me signal been given within 10 m.secs. of the interrupt occuring the Overdue digit is set, the punch is stopped and no further interrupts occur.

8.4 Continued

g) Do not Off-set Card (digit 29)

This digit is automatically reset to zero to indicate "Off-Set Card" at the time the first row signal should be given by the punch station whether or not a card is actually passing through the punch station. It is set by program to "Do Not Offset Card" when the End of Card signal is received if the count of the rows for both stations has been correct, no overdue signals have been received and if the information read by the checking station was the same as that sent to the punch station. This digit is examined 9 m.secs. after the End of Card signal and the card off-set if the digit has not been reset by the program.

h) Card Levels (digit 39)

This is set, and the Stop/Start flip-flop set to Stop, two m.secs. after the next End of Card signal is given if Operator attention is required because either

(i) the card magazine is empty or
(ii) the card receiver is full.

The digit is reset automatically when the card level in question has been attended to.

i) Card Wreck (digit 38)

This is set and the reader stopped 2 m.secs. after the next End of Card signal if Engineer attention is required because a card wreck, jam or misfeed has occurred. The appropriate digit is reset automatically, provided the fault condition has been corrected when the Engage button is pressed.

j) Overdue (digit 37)

This is set and the punch stopped immediately if the appropriate Put Out Look At Me signal is not sent either:

(i) within 35 m.secs. of a Punch Look At Me
(ii) within 10 m.secs. of a Brush Look At Me
(iii) within 10 m.secs. of an End of Card Look At Me

The Overdue digit is reset either when the Engage button is pressed or by writing a one to digit 38.

In each of the above three cases (i.e. either digit 39, 38, or 37 set and the reader stopped) the reader is disengaged by fixed store program.

8.5 Paper Tape and Teleprinter Output

8.5.1. The Teletype Punch

The Teletype punch operates at up to 110 characters per second punching either five or seven channel paper tape. There is no facility, e.g. switch or push button, for the operator to convert a punch from five to seven channel operation, and vice versa, but the change can be made by an engineer by the repositioning of a package and by changing the position of the tape guide. A maximum of twelve teletype punches is permissible and of these, punches 0 - 7 always operate in the seven channel mode and punches 8 - 11 always operate as five channel punches.

The V-store Digits

Type 8

line	digits		
0	35-29	W1	Information, seven channel punches
(8	33-29	W1	Information, five channel punches)
	27	RW1	Read: Disabled
			Write: Start
	26	RW1	Read: Tape Warning
			Write: Put Out Look At Me
	25	RW1	Read: Stopped
			Write: Stop
	24	RW1	Read: Disengaged
			Write: Disengage

Type 14

8	24	R	Punch Look At Me

To Engage a punch it is necessary to press the Engage button on the punch; it is not possible to engage a punch directly from the computer. Pressing the Engage button resets the Disengaged digit in the V-store to zero (digit 24 of the appropriate line of Type 8). When the Supervisor wishes to output on a punch it examines the Disengaged digits of the punches not already in use and if one of these digits is read as a zero that punch is used for the output. If all the punches not in use are disengaged the Supervisor instructs the operator to engage one. The disengaged digits are examined during the "one second interrupts" and if a punch is subsequently engaged the output is commenced. If one of the other punches, i.e. one of those previously being used, becomes available before a further one is engaged by the operator this is used for the output.

After a punch is engaged it is necessary to write a one to the Start digit (digit 27) before sending characters to be punched. This digit remains set until the Stop digit (digit 25) is set which may be done either

a) by writing a one by programme to the Stop digit

b) by writing a one by programme to the Disengage digit

c) by pressing the Disengage push-button

The character to be punched is held in the V-store until the appropriate time in the punch cycle for it to be punched. The V-store digits are then cleared and a further Look At Me signal given.

If the Stop digit is set, either from the computer or by pressing the Disengage button, no further Look At Me signals are given. The Look At Me signal may be given between 5 μsecs and 9 m.secs after the previous character has been punched.

8.5.1. Continued..

Therefore to prevent a further Look At Me being given after the last character in a block of output has been punched the Stop command must be given within 5 μsec of copying the character to the V-store and giving the Put Out Look At Me signal. In effect this means that the Stop signal must be given simultaneously with the last character.

If the Disengage button is pressed after a Look At Me signal has been sent to the machine this interrupt is dealt with in the normal way and the character sent to the V-store is punched. The setting of the stop digit is detected by the Supervisor in the next One Second Interrupt.

If the stop digit remains set for about 30 secs the motor is automatically run down.

Digit 27 (Disabled) is read as a one and the Stop/Start flip-flop is set to Stop if a fault (power off only) is detected by the punch. The punch is disengaged by fixed store program. The digit is reset automatically when the fault has been corrected. It is not possible to re-engage the punch whilst the fault still exists.

A Tape Warning digit (digit 26) is set in the V-store when the diameter of the tape reel is such that only 40 feet of tape remains. The setting of this digit depends on a mechanical arrangement and obviously the amount of tape remaining when it is first set cannot be guaranteed to within a few feet. This digit is reset automatically when the contact is broken.

The same digit is set and the Stop/Start digit set to Stop when a Tape Out or Tape Torn condition is detected. In this case the punch is disengaged by fixed store program. The digit is reset automatically when the fault condition is corrected. The punch cannot be re-engaged whilst the fault condition exists. The punch may stop, depending on when the warning is given, either with the character resulting from the last Look At Me stored but not punched or having punched the last character. In either case it is essential that the fixed store program is able to restart the output at some earlier point.

A Run Out button on the punch outputs blank tape (figure shift) for five channel tape and the three least significant bits of a character (upper case) for seven channel tape. If the run out button is pressed at a time when the punch is operating the character resulting from the last Look At Me is either

a) stored but not punched or

b) punched.

In case a) the character is punched after the run out button is released, the Look At Me also being set.

Normal output is resumed when the run out button is released, the fixed store program not being aware of the run out characters having been inserted in the output.

The location hole is punched between digits 31 and 32. The bit sent to digit 29 is always punched in the outside channel on the 3-channel side of the tape. For five channel tape the bit sent to digit 33 is punched in the outside channel on the two channel side of the tape. For seven channel tape the bit sent to digit 35 is punched on the outside channel of the four channel of the tape. For correct punching a seven channel teletype can only be connected to one of the positions 0 - 7 of type 8 and a five channel teletype can only be connected to one of the positions 8 - 11. The fixed store program determines from its address whether a teletype is seven or five channel.

8.5.2 The Teleprinter

This is a Creed Model 75 teleprinter which operates at 10 characters per second. It has six information channels with all its characters on a single shift. The characters available are:

Space	0	, (comma)	p
* (asterisk)	1	a	q
N.L.	2	b	r
(red)	3	c	s
(black)	4	d	t
π (pi)	5	e	u
] (close square brackets)	6	f	v
[(open square brackets)	7	g	w
(	8	h	x
)	9	i	y
<	α (alpha)	j	z
>	β (beta)	k	?
:	$\frac{1}{2}$	l	=
_ (underline)	+	m	' (prime)
| (vertical bar)	-	n	& (and)
/ (oblique stroke)	. (point)	o	ER (erase)

The V-store digits

Type 11

line	digits		
0	35,34,32-29	W1	Information
	27	RW1	Read: Disabled
			Write: Start
	26	RW1	Read: Paper Warning
			Write: Put Out Look At Me
	25	RW1	Read: Stopped
			Write: Stop
	24	RW1	Read: Disengaged
			Write: Disengage

Type 14

line	digit		
1	24	R	Print Look At Me

The operation of the teleprinter is the same as that for the Teletype punch described in the previous section. Digit 33 in line 0 corresponds to the parity digit in the seven-channel Flexowriter code and is not used in the teleprinter code. This enables the teleprinter and a seven-channel Teletype punch to be interchanged provided that the character sets being used are common to both equipments.

A delay is built into the teleprinter to prevent printing during the Carriage Return/Line Feed operation.

8.5.3. Creed 3000 Paper Tape Punch

This punch operates at up to 300 characters per second punching seven-channel tape. The punch can also be set up to punch 5, 6 or 8 channel tape although for punching 5-channel tape a different block is required.

The V-store digits

Type 6

line	digits		
0	35 - 29	W1	Information
	28	RW1	Read: Check Fail Write: Reset Check Fail
	27	RW1	Read: Disabled Write: Start
	26	RW1	Read: Tape Warning Write: Put out Look At Me
	25	RW1	Read: Stopped Write: Stop
	24	RW1	Read: Disengaged Write: Disengage

Type 14

line	digit	
14	24	Punch Look At Me

The Creed 3000 punch is operated in a similar manner to the Teletype punch except that it also contains a Check Read station. This reads a character by means of photocells three characters after it has been punched. This character is compared, within the punch, with the character expected and the Check Fail (digit 28) and Stop signals are sent in the event of a discrepancy. This digit is reset by writing a one to the Reset Check Fail digit (also digit 28).

Digit 27 (Disabled) is set to a one and the Stop/Start flip-flop set to Stop if a failure of the punch occurs e.g. a power failure or one or both of the covers are open. The digit is reset to zero automatically when the fault condition is cleared.

The location hole is punched between digits 31 and 32. The bit from digit 29 is punched in the outside channel on the 3-channel side of the tape and the bit in digit 35 is punched in the outside channel on the 4-channel side of the tape.

8.6. Paper Tape Input

8.6.1. The TR5 Paper Tape Reader

The TR5 operates at up to 300 characters per second reading either five or seven channel tape. There is a Honeywell double-action switch and indicator on the reader to select whether five or seven channel tape is to be read. This button must be pressed to change the mode of reading. The upper half is lit (Yellow) when reading seven-channel tape and the lower half is lit (blue) for five channel tape. If this is set to read five channel tape the digits in the other two channels are always read as zero. There is also a mechanical guide which must be placed appropriately for either five or seven channel reading. This guide is independent of the push-button.

The V-store Digits

Type 7 (*60041600)

line	digits		
0	34	R	Overdue
	33	R	5/7 switch (1 if 5-channel)
	32-26	R	Information
	28	W1	Reset Overdue
	27	W1	Start
	26	W1	Put Out Look At Me
	25	RW1	Read: Stopped
			Write: Stop
	24	RW1	Read: Disengaged
			Write: Disengage

Type 14 (*60043530)

11	24	0	Character Look At Me

To Engage the reader it is necessary to press the Engage button; it is not possible for the reader to be Engaged directly by the computer. Pressing the Engage button resets the Disengage digit in the V-store to zero. This digit is examined by the peripheral supervisor during the "one second interrupt" programme and the reader may be started if it has been Engaged. The reader can be disengaged either by writing a one to the Disengage digit from the computer or by pressing the Disengage button. In either case the tape is stopped with a character stored in the information digits in the V-store. When the reader is engaged and started again a Look At Me interrupt occurs immediately and this character is transferred to the computer. The Supervisor can distinguish between when a reader is newly engaged and when it has been disengaged and re-engaged (e.g. because the tape is twisted and requires operator attention) because in the latter case the input has been terminated without any appropriate "End of Tape" characters having been read.

After the Start signal has been sent to the reader, characters are read at the rate of 300 per second to the information digits (26-32) of the appropriate V-store line. On both 5 and 7 channel tape the location hole is between digits 28 and 29, digits 31 and 32 being zero for 5-channel tape. In both cases the outside digit on the 3-channel side of the tape is read to digit 26. For 7-channel tape the outside bit on the 4-channel side of the tape is read to digit 32 and for 5-channel tape the outside bit on the 2-channel side of the tape is read to digit 30.

The Look At Me digit is set, causing an automatic interrupt, as the sprocket hole is passing under the reader. The character is available in the information digits from the time the Look At Me digit is set coinciding with the "late location hole" signal to the time the "early location hole" signal for the next character is received. The time between the "early" signal, when the information digits are reset, and the "late" signal, when the next character is available, is about 2 μsecs. The Look At Me normally remains on until put out by the fixed store programme.

8.6.1. Continued..

Digit 34 (Overdue) is read as a one and the reader stopped if the Put Out Look At Me signal for a character has not been sent by the time the information staticisors are cleared for the next character (about 2u.s. before the character is available). The reader is disengaged by fixed store program and the digit is automatically reset when the reader is disengaged. The digit may also be reset by writing to digit 28. The tape comes to rest after reading this next character, the original character in the information digits having been cleared and the new character written in.

The reader may be stopped either

a) by a command from the computer

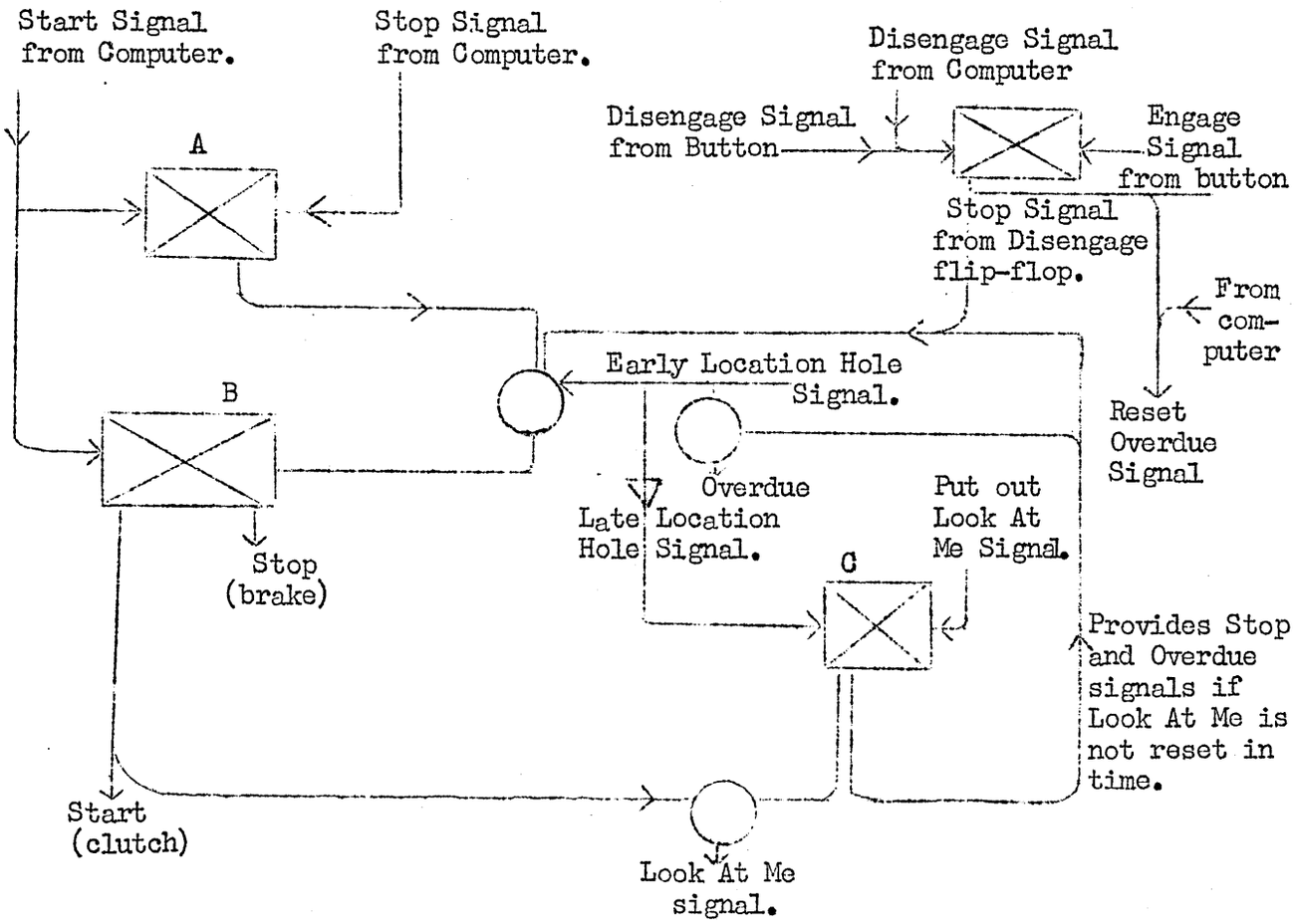
b) by the operator pressing the Disengage button or

c) when the Look At Me is not reset by the computer within the appropriate time.

The Supervisor has to allow for the cases where the One Second Interrupt finds a reader disengaged or stopped (having been disengaged and re-engaged) due to operator intervention and when it finds the reader stopped due to a character having been missed. In this latter case the reader may also have been disengaged manually about the same time.

From the diagram below it can be seen that after a Start signal is given the clutch is engaged and a Look At Me interrupt occurs when the first location hole is detected, or immediately if the appropriate flip-flop C is already set.

Flip-flop B is reset to Stop and the clutch disengaged when a Stop or Disengage signal is received and a location hole signal is detected. After a Stop signal is given flip-flop C is set when a location hole is detected, a character is read to the information digits, but no automatic interrupt occurs. A character is thus available to be read by the computer from the information digits immediately a further start signal is received.



8.6.2 The T.R.7 Paper Tape Reader

General

The T.R.7 operates at up to 1,000 characters per second reading either five or seven channel tape. Automatic spooling is provided to facilitate the handling of long tapes although it is possible to use the reader without using the automatic spooling. A reel of tape is loaded onto the right hand capstan and is taken up on the left hand spool. A fast rewind facility enables an 1,100 ft. tape to be rewound in approximately 30 seconds. If the automatic spooling is being used the first and last ten feet of the paper tape must be blank (or not containing relevant punching) i.e. tapes which are less than twenty feet in length must be read without using the spools. Tapes which are longer than twenty feet may be used either with (in which case there must be the ten feet of blank tape at either end) or without the spooling facility. If the spooling facility is not used then the reel of tape is dropped into the right-hand trough of the reader. The tape which has been read is passed out through the left-hand side of the reader and can be collected in a tape bin. In this case there must be twenty inches of blank tape at the beginning of the reel.

The V-store digits

Peripheral V-store, Type 2 (*60040400)

Line	Digits		
0	36	R	Disabled
	35	R	Tape Warning
	34	R	Overdue
	33	R	5/7 Channel switch (1 for 5-channel)
	32-26	R	Information
	30	W1	Stop Rewind
	29	W1	Rewind
	28	W1	Reset Overdue
	27	W1	Start
	26	W1	Put out Look At Me
	25	RW1	Read: Stopped Write: Stop
	24	RW1	Read:Disengaged Write: Disengage

Type 14 (*60043640)

20	24	R	Look At Me

Push-Buttons and Indicators

There are nine buttons and/or indicators on the front on the T.R.7.Eight of them are grouped together in the centre of the reader and the other (Mains On/Off) is placed separately. The purposes and effects are given below together with the colours of the lights behind the buttons which are lit to indicate the relevant states.

1) Mains ON/OFF

This is a double action button and pressing it changes its state from On to Off or from Off to On as appropriate. When switched to On, it switches on the power supplies, the cooling fans, the reading head light and the pilot lights (used by the servo system) in the tape troughs. Its colour is Green when the reader mains are switched on.

2) Engage

This is a single action button and when pressed the following actions take place:-

a) the tape is clamped in the region of the reading head,

8.6.2. Continued..

b) the drive-unit motor is switched on,

c) the Green light comes on immediately

d) the complete servo-system becomes operational if the spooling facility is being used i.e. the reader is in the "with spooling" mode,

e) the new state of the Engage flip-flop is sent to the computer setting digit 24 of the appropriate V-store line to zero to read as Engaged, after about five seconds. This delay is so that if the "With Spooling" mode is being used this signal is sent only after the tapes in the troughs have been servoed into the correct positions. This button is lit White when the reader is disengaged and Green when it is engaged. It remains Green if the computer initiates a Rewind without also disengaging the reader.

3) Disengage

This is a single action button and when pressed the following actions take place:-

(a) the drive-unit motor is switched off,

(b) if in the "With Spooling" mode the servo system is switched off, the spools being held stationary. The suction fan remains running, this being switched off during "Reload" or "Without Spooling" conditions.

(c) a disengaged signal is sent to digit 24 of the appropriate line of the V-store immediately.

If the computer sends a Disengage signal or the Disengage button is pressed at the same instant as the Engage button is pressed the reader takes up the Disengaged condition. If the reader is disengaged during the delay period between pressing the Engage button and the Engaged signal being sent the normal action taken on disengaging the reader occurs and no Engaged signal is sent to the computer.

This button is lit White when the reader is engaged and Red when it is disengaged.

4) 5 Track/7 Track

This is an alternate action switch which either switches out or in the two additional channels of information. The masking plate and the front panels of the suction troughs have to be adjusted manually. The top half of this button is Yellow when 7-track reading is selected and in darkness when 5-track reading is selected. The lower half is in darkness for 7-track reading and Blue for 5-track reading.

5) Started/Stopped Indicator

This is an indicator which is lit Blue when the reader is Started (i.e. the Start/Stop flip-flop reads Started) and is White when the reader is Stopped.

6) Rewind

This is a single-action switch which, provided that the reader is disengaged and in the "With Spooling" mode, when pressed initiates a fast rewind of the tape. The reader cannot be Engaged during a rewind operation. The tape is stopped a short distance from the beginning by means of a metallic strip attached to the tape and a pick-up arm. The tape can then be re-read without reloading. If it is not required to re-read the tape the metallic strip can be left off the tape and in this case the reader stops rewinding when all the tape has been rewound. The spool drive motors are switched off at the end of a rewind on a signal from the pick-up arm. This is given either on contact with the metallic strip or when it comes into contact with the hub of the spool due to the tape having been rewound completely. Pressing the button or attempting to initiate a rewind from the computer when a rewind is in progress has no effect. Attempting a second rewind after a previous one has been completed has no effect if the tape has already been wound off the left hand spool. If the first rewind were stopped by contact between the pick-up arm and the metallic strip a second rewind is performed which is stopped after the tape has been wound off the left hand spool.

8.6.2. Continued..

A rewind will not start if the pick-up arm is in contact with the metallic strip.

This button is lit White when the reader is disengaged and in the "With Spooling" mode but is not rewinding (i.e. when a rewind may be initiated) and Red at all other times.

7. Stop Rewind.

This is a single action switch and, provided that the reader is rewinding, when pressed it stops the rewinding of the tape. For a rewind initiated from the computer without the reader being disengaged, pressing this button stops the rewind and also disengagesthe reader.

The button is lit White during a rewind and Red at all other times.

8. Reload/Ready

This is a single action switch which must be pressed before a tape can be loaded or unloaded. Pressing this button when the reader is engaged or is rewinding has no effect. Pressing the button when the reader is disengaged (and not rewinding) unclamps the tape at the reading head and switches off the suction fans to facilitate the appropriate loading or unloading operation to take place during the subsequent "Ready" (i.e. Ready for reload) period.

After a "Reload" operation the reader is made operational again by pressing either the "Engage" or the "Rewind" button. (The latter case is only effective in the "With Spooling" mode).

A change from "With Spooling" to "Without Spooling" or vice-versa can only be done during the "Ready"period.

The top half of this button (Reload) is lit White when the reader is disengaged and not rewinding (i.e. when a Reload may take place) and in darkness at all other times. The lower half of the button is lit Blue (Ready) when the fans are switched off and the actual reloading operation can take place (the top half is still lit White at this time) and is in darkness at all other times.

9. With Spooling/Without Spooling

This is an alternate action switch effective only when the reader is in the "Reload Ready" condition. When pressed it either switches on or off the servo system, in the latter case allowing tape to be read without using the spools.

The top half, With Spooling, is lit Blue when the servo system is on; it is lit White when the servos are off and the reader is in the Reload Ready state; otherwise it is in darkness.

The bottom half, Without Spooling, is lit Yellow when the servos are off; it is lit White when the servos are on and the reader is in the Reload Ready state; otherwise it is in darkness.

<u>Reloading</u>

The reader can only be reloaded if it is disengaged and not rewinding. This is indicated by the top half of the Reload/Ready button i.e. the top half is lit White when a tape can be loaded or unloaded. When the Reload/Ready button is pressed the bottom half lights up Blue to indicate that the fans are off, the tape is unclamped and the reader is Ready to be reloaded.

A tape is then reloaded as follows:

1) The pick-up arm is moved manually to its reload position,

2) the right hand spool is rotated in an anti-clockwise direction until all the tape has been wound onto it,

3) the right hand spool is removed and replaced by a new one. This new spool is fitted so that rotation in a clock-wise direction unwinds the tape,

8.6.2. Continued..

4) the end of the tape is passed between the right hand roller and microswitch, under the clamping mechanism between the left hand roller and microswitch, and wound onto the left hand spool in such a manner that rotation of the spool in a clockwise direction winds the tape on. The tape is loaded so that the outside track of the 3 track side of the tape is the nearer to the reader for both 5 and 7 track tape,

5) the left hand spool is rotated until the metallic strip (if being used) on the tape is wound past the pick-up head,

6) the pick-up arm is released from its reload postion manually,

7) the "With Spooling/Without Spooling" button is pressed if appropriate,

8) the Engage button is pressed. The light behind the lower half of the button (Ready) goes out. The green light behind the Engage button and the White light behind the Disengage button come on immediately. The suction fans come on, the fan run-up relay is actuated and, when completed, the servo system is operated; after a delay of about 5 seconds an Engaged signal is sent to the computer.

Signals to and from the Computer.

To engage the reader it is necessary to press the Engage button; it is not possible for the reader to be engaged directly by the computer. Pressing the Engage button resets the Disengaged digit in the V-store (digit 24) to read as zero provided neither the Disabled digit nor the Tape Warning digit is set. If either of these digits isset pressing the button has no effect. The Disengaged digit is examined by the peripheral supervisor during every "One Second Interrupt" and the reader may be started, by the fixed store programme, if it has been engaged.
The reader can be disengaged either (a) by the computer writing a one to the Disengage digit or (b) by an operator pressing the Disengage button or (c) by an operator pressing the Stop Rewind button during the course of a rewind initiated by the computer. If in the first two cases, the Start/Stop flip-flop for the reader was set to Started a further character is read and stored in the information digits of the V-store before the reader is stopped and disengaged. When the reader is re-engaged and re-started a Look At Me signal is given immediately and this character is transferred to the computer.

After the Start signal has been sent to the reader characters are read at the rate of 1,000 per second to the information digits (26-32) of the appropriate V-store line until the reader is stopped. The sprocket hole on the tape is between the digits read to positions 28 and 29 i.e. the digit in the outside track on the 3-track side of the tape is always read to digit 26. For five track tape the digit on the outside track of the 2-track side of the tape is read to digit 30, and for seven track tape the digit on the outside track of the 4-track side of the tape is read to digit 32. If the 5-track/7-track switch is set to 5 Track (digit 33 reading as a one) digits 31 and 32 are always zero.

The Look At Me signal is sent, causing an automatic interrupt, as the sprocket hole is passing under the reader. The character is available in the information digits from the time the Look At Me is given, coinciding with the "late location hole" signal to the time the "early location hole" signal for the next character is received. The time between the "early" signal, when the information digits are reset, and the "late" signal, when the next character is available is about 5μ secs.

The Look At Me normally remains on until put out by the fixed store programme. If however, it has not been extinguished by the time the next character is due to be copied into the information digits an Overdue digit (digit 34) is set and the Start/Stop flip-flop set to Stopped. The tape comes to rest after reading this next character, the original character in the information digits having been cleared (and hence lost to the computer) and the new character written in. The setting of this Overdue digit is detected by the "One Second Interrupt" and the digit is reset either automatically when the reader is disengaged (either from the machine or by push button) or by the machine writing a one to the "Reset Overdue" digit (digit 28).

8.6.2. Continued..

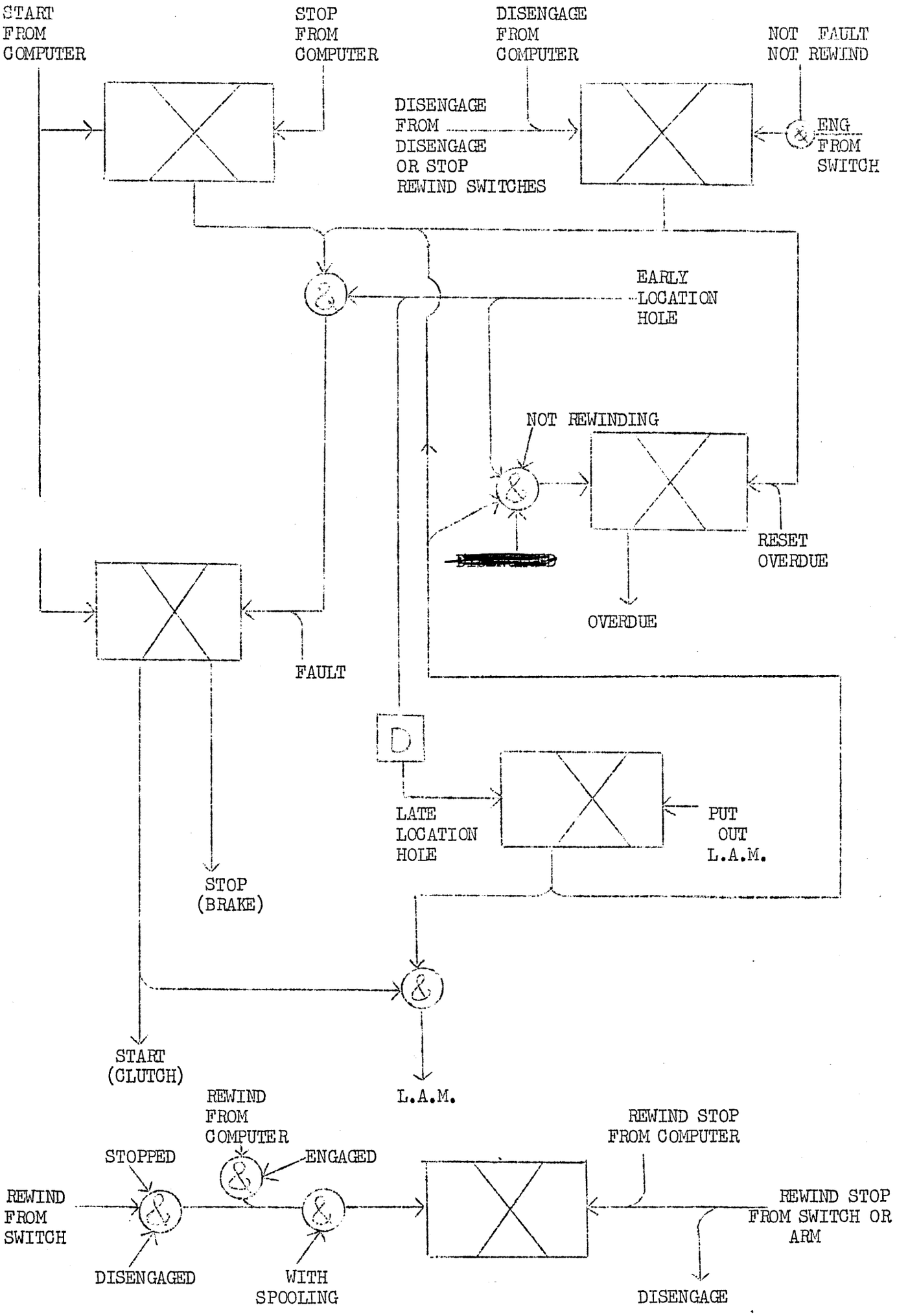
Digit 36 (Disabled) is set and the Start/Stop flip-flop set to Stopped if a fault condition is detected automatically by the reader. (The fault conditions are (a) fuses blown (b) door open). The reader is disengaged by fixed store programme at the next one second interrupt and the digit is reset automatically when the fault has been corrected. The reader cannot be re-engaged whilst the fault digit is still set.

Digit 35 (Tape Warning) is automatically set and the Start/Stop flip-flop set to Stopped if the tape runs out or is broken. This condition is only detected during the "With Spooling" mode of the reader. The reader is disengaged by fixed store programme during the next one second interrupt after digit 35 is set. A Tape Torn or Out condition can be detected either by a "tape tensioning" microswitch or by the failure to receive a character at the reading head within 200 m. secs of the last one when the reader is started. This digit is reset automatically either (a) when the fault is corrected if it was detected by a microswitch or (b) when the Reload button is pressed if the fault was detected at the reading head. The reader cannot be re-engaged whilst the fault digit is set.

There are two microswitches for detecting the tape out or tape broken conditions, one between the right hand spool and the reading head and the other between the reading head and the left hand spool. The pick-up arm associated with detecting the end of a rewind does not set the Tape Warning digit.

Digits 29 and 30 are used to control the Rewind facility from the computer. This is only effective when the "With Spooling" mode is selected and the reader is Engaged. (Rewind from the push button is only possible when the "With Spooling" mode is selected and the reader is Disengaged). When a rewind order is given from the computer the reader appears to the computer to be temporarily disengaged i.e. digit 24 reads Disengaged, but the Green light behind the Engage button and the White light behind the Disengage button both remain on. If the tape is moving the computer must send a Stop signal before initiating a rewind. During a rewind the characters on the tape are read into the V-store information digits as they pass under the reading head but no Look At Me signals are given (inhibited because the Stop/Start flip-flop is set to Stopped) and the state of the Overdue digit is not changed.

At the completion of the Rewind (beginning of tape or a Stop Rewind order given by the computer) the reader automatically resumes the Engaged state again. If however a Disengage command is sent to the reader from either the computer or the Disengage push button after the Rewind order the reader does not resume the engaged state again. If it is required to send both Rewind and Disengage commands to the reader the Rewind order must be sent first. If they are sent simultaneously the Rewind order may not be effective. If the "Stop Rewind" button is pressed during the course of a rewind initiated by the computer the rewind is stopped and the reader disengaged i.e. digit 24 remains set at one and the lights behind the Engage and Disengage buttons changed to White and Red respectively.



SIMPLIFIED LOGICAL DIAGRAM OF THE T.R.7

8.7 Character Codes

8.7.1 A Description of the Internal Character Code

Atlas uses several different typesof peripheral equipment each of which has its own character code. An internal character code has been chosen so that programs or data may be fed in on any relevant medium (seven channel paper tape i.e. Flexowriter code, five-channel paper tape, i.e. Mercury/Pegasus code, cards punched in I.B.M. code, N.E.P. tape, or I.B.M. magnetic tape) and appear in the machine in exactly the same form, the translation being done character by character while the tape or card is read. Similarly for output the conversion to the code for the specified equipment is done character by character. This means that a program which confines its output to the limited range of characters common to all equipments may send this output to any punch or printer. Only those programs which produce a wider range of characters have to specify the type of equipment to be used.

The characters available on the different equipments are divided into an "inner set" and an "outer set". As a six bit code is used a total of 128 different characters including the shift characters can be represented. With the exception of "<", "&", and "backspace", the inner set of characters is common to all output peripherals.

Input

During input each character is checked for correct parity (if on seven-channel tape) or correct punching (if on a punched card) and converted to its internal code equivalent. Every permitted character on the input has one and only one equivalent in the internal code. The paper tape characters Figure Shift, Letter Shift, Upper Case and Lower Case are not normally stored in the internal code but their significance is noted by the fixed store program. The "Shift in" and "Shift out" characters of the internal code are inserted automatically by the fixed store program where appropriate. Redundant shifts, however, are stored (e.g. letter shift when on letter shift and upper case when on upper case) so that the main program can make its own checks against spurious characters.

The carriage control characters NL, CR, LF, Paper Throw, and also End of Card, are treated differently from the normal printing characters. Information in the internal code is stored in "records"; each record corresponding to a line of paper tape input or one card. When one of the carriage control characters is detected on input the count of the number of characters in the record is recorded, and the carriage control character is inserted at the end of the record. In effect, the six-bit carriage control character belongs to a third character set, distinct from the inner or outer sets; it is recognised only by being the last character in each record.

Each internal code record is assumed to start in the inner set, no matter how the previous record ended. If the first printing character in any record is in fact an outer set character, the input routine will precede it with the "shift out" character even though the previous record may have ended in outer set.

If an inadmissible punching on a card, or a parity error on paper tape is detected the character is replaced by the "Fault" character if the computer is operating in the mode where the programmer does not wish it to stop reading on detecting an error.

Output

On output each character is checked as being permissible for the particular equipment being used. If it is unsuitable it is replaced by the "." (full stop) character.

8.7.1. Continued

A programmer may include F.S., L.S., U.C., and L.C., characters for output on paper tape, if desired, and these will appear where specified. This is not essential however for the fixed store program automatically inserts the appropriate characters where necessary.

Output which has originated as input from another peripheral will contain only the limited set of carriage control characters: NL, CR, LF, Paper Throw, or End of Card (=NL) as appropriate. But when output is originated by program, the program is able to specify paper throwing with or without carriage return, and line feeding with or without carriage return. Owing to the way the different printers are made it is not always possible for these instructions to be obeyed precisely. In these cases, a compromise is made according to the following rules:

a) Paper throwing: the channel number n is interpreted module m, where m is the number of homing channels available on a printer. If no paper throwing facility exists on the printer, the output routine initiates one line feed instead.

b) Line feeding: the number of line feeds performed is always correct, $0 \leqslant n \leqslant 15$.

c) Carriage return is performed (if requested) only if it can be done while still retaining the correct number of line feeds.
Carriage return is performed (even though not requested) if this is necessary in order to achieve the correct number of line feeds.

d) Repeated spaces or backspace are not inserted by the output routines in any attempt to position the carriage correctly.

In order that on output equipments Tab., UC, LC, and Lower case letters are treated as usefully as possible, on the

Anelex
Tab. is treated as one space.
UC is ignored.
LC is ignored
All outer set letters a-z are printed as inner set letters A-Z.

Card Punch
Tab. is treated as one space
UC is ignored.
LC is ignored
All outer set characters a-z are punched as inner set characters A-Z.

5 Channel Teletype
Tab. is treated as one space.
All outer set characters a-z are punched as inner set characters A-Z.

Binary

Instead of having the input and output information automatically translated to or from the internal code by a fixed store routine it is possible to specify "binary" input or output. When this mode is specified the fixed store program simply copies the pattern of 0's and 1's from the input device to the computer or from the computer to the output device.

8.7.1. Continued

A complete binary paper tape is stored as a single record on input. Each card is also stored as a single record. The carriage control character is zero in both cases.

Binary output which has originated from program may contain any carriage control character, but whatever character is found by the output routine it is ignored when punching paper tape, and causes a single card feed when punching cards.

8.7.2 The Internal Character Code

Inner set

Character	Internal code (octal)	Flexowriter code (binary bits & shift)	Five hole code (binary bits & shift)	IBM Fortran card code (holes punched)	Anelex (bits 35-27 octal)
(Unassigned)	00	** 0000.001	..	..	..
Space	01	** 0010.000	FS 01.110	None	300
Tabulate	02	** 0000.100	..	..	..
Backspace	03	** 0010.101	..	..	..
Shift to outer set	04	..	..	..	..
Shift to inner set	05	..	..	..	..
Shift to LC/LS	06	** 0010.110	** 11.011	..	..
Shift to UC/FS	07	** 0000.111	** 00.000	..	..
(Open brackets	10	LC 0111.000	FS 10.100	0,4,8	234
) Close brackets	11	LC 0101.001	FS 01.100	+,4,8	240
, Comma	12	LC 0101.111	FS 11.110	0,3,8	266
π Pi	13	LC 0111.011	LS 01.111	-,3,8	272
? Query	14	LC 0101.100	LS 10.111	-,5,8	364
& Ampersand	15	LC 0111.101	..	5,8	330
* Asterisk	16	LC 0111.110	FS 11.000	-,4,8	344
/ Oblique	17	UC 0011.111	FS 11.101	0,1	350
0 Zero	20	UC 0100.000	FS 00.001	0	202
1	21	UC 0110.001	FS 10.000	1	306
2	22	UC 0110.010	FS 01.000	2	312
3	23	UC 0100.011	FS 11.001	3	216
4	24	UC 0110.100	FS 00.100	4	322
5	25	UC 0100.101	FS 10.101	5	226
6	26	UC 0100.110	FS 01.101	6	232
7	27	UC 0110.111	FS 11.100	7	336
8	30	UC 0111.000	FS 00.010	8	342
9	31	UC 0101.001	FS 10.011	9	246
< Less than	32	LC 0100.011	..	0,5,8	352
> Greater than	33	LC 0110.100	FS 10.001	+,5,8	354
= Equals	34	LC 0100.101	FS 01.010	3,8	256
+ Plus	35	UC 0111.101	FS 01.011	+	314
- Minus	36	UC 0111.110	FS 11.010	-	210
. Point	37	UC 0101.111	** 00.111	+,3,8	220

Notes

**	: This paper tape character appears in both paper tape shifts.
(Unassigned)	: There is no printing symbol corresponding to this internal code character.
U.C. and L.C.	: These are ignored by the peripheral supervisor for equipments where they have no relevance.
Anelex codes	: The three octal digits given include the information strobe.
Tabulate	: Tabulate is treated as a single space by the peripheral supervisor on output equipments where it does not otherwise exist.

Inner set (Continued)

Character	Internal code (octal)	Flexowriter code (binary bits & shift)	Five hole code (binary bits & shift)	IBM Fortran card code (holes punched)	Anelex (bits 35-27 octal)
' Apostrophe	40	LC 0100.000	FS 10.111	4,8	244
A	41	UC 1010.001	LS 10.000	+,1	356
B	42	UC 1010.010	LS 01.000	+,2	360
C	43	UC 1000.011	LS 11.000	+,3	262
D	44	UC 1010.100	LS 00.100	+,4	264
E	45	UC 1000.101	LS 10.100	+,5	366
F	46	UC 1000.110	LS 01.100	+,6	270
G	47	UC 1010.111	LS 11.100	+,7	372
H	50	UC 1011.000	LS 00.010	+,8	374
I	51	UC 1001.001	LS 10.010	+,9	276
J	52	UC 1001.010	LS 01.010	-,1	200
K	53	UC 1011.011	LS 11.010	-,2	302
L	54	UC 1001.100	LS 00.110	-,3	304
M	55	UC 1011.101	LS 10.110	-,4	206
N	56	UC 1011.110	LS 01.110	-,5	310
O	57	UC 1001.111	LS 11.110	-,6	212
P	60	UC 1110.000	LS 00.001	-,7	214
Q	61	UC 1100.001	LS 10.001	-,8	316
R	62	UC 1100.010	LS 01.001	-,9	320
S	63	UC 1110.011	LS 11.001	0,2	222
T	64	UC 1100.100	LS 00.101	0,3	224
U	65	UC 1110.101	LS 10.101	0,4	326
V	66	UC 1110.110	LS 01.101	0,5	230
W	67	UC 1100.111	LS 11.101	0,6	332
X	70	UC 1101.000	LS 00.011	0,7	334
Y	71	UC 1111.001	LS 10.011	0,8	236
Z	72	UC 1111.010	LS 01.011	0,9	340
(Unassigned)	73	UC 1101.011	..	..	..
(Unassigned)	74	UC 1111.100	..	..	..
(Unassigned)	75	UC 1101.101	..	..	..
(Unassigned)	76	UC 1101.110	..	..	..
Fault	77	..	..	..	..

Notes

** : This paper tape character appears in both paper tape shifts.

(Unassigned) : There is no printing symbol corresponding to this internal code character.

Anelex codes : The three octal digits given include the information strobe.

Outer Set

Character	Internal code (octal)	Flexowriter code (binary bits & shift)	Five hole code (binary bits & shift)	IBM Fortran card code (holes punched)	Anelex (bits 35-27 octal)
(Unassigned)	00	** 0000.001	..	..	..
Space	01	** 0010.000	FS 01.110	None	300
% Percent	02	..	..	..	..
£ Pound sterling	03	..	..	..	324
Shift to outer set	04	..	..	..	..
Shift to inner set	05	..	..	..	...
Shift to LC/LS	06	** 0010.110	** 11.011	..	..
Shift to UC/FS	07	** 0000.111	** 00.000	..	..
(Unassigned)	10	** 0001.000	..	..	..
(Unassigned)	11	** 0011.001	..	..	..
(Unassigned)	12	** 0011.010	..	..	..
(Unassigned)	13	** 0001.011	..	..	..
(Unassigned)	14	** 0011.100	..	..	..
(Unassigned)	15	** 0001.101	..	..	..
(Unassigned)	16	** 0001.110	..	..	..
: Colon	17	LC 0011.111	..	6,8	242
ø Phi	20	..	FS 00.011	..	..
[Open square brackets	21	LC 0110.001	..	-,7,8	346
] Close square brackets	22	LC 0110.010	..	-,6,8	250
->Arrow	23	..	FS 00.101	..	..
≥ Greater or equal	24	..	FS 01.001	..	..
≠ Not equal	25	..	FS 10.010	..	..
_ Underline	26	LC 0100.110	..	+,6,8	260
| Vertical bar	27	LC 0110.111	..	+,7,8	362
² superscript 2	30	LC 0101.010	..	..	370
≂ Curly equal	31	..	FS 00.110	..	..
α Alpha	32	UC 0101.010	..	..	274
β Beta	33	UC 0111.011	..	..	376
½ Half	34	UC 0101.100	..	..	204
10 Ten	35	...	...	..	252
11 Eleven	36	..	...	..	254
(Unassigned)	37	UC 1000.000	..	..	...

Notes

**	: This paper tape character appears in both paper tape shifts.
(Unassigned)	: There is no printing symbol corresponding to this internal code character.
Anelex codes	: The three octal digits given include the information strobe.
U.C. and L.C.	: These are ignored by the peripheral supervisor for equipments where they have no relevance.

Outer Set (Continued)

Character	Internal code (octal)	Flexowriter code (binary bits & shift)	Five hole code (binary bits & shift)	IBM Fortran card code (holes punched)	Anelex (bits 35-27 octal)
(Unassigned)	40	LC I000.000	..	..	..
a	41	LC I0I0.00I	..	..	..
b	42	LC I0I0.0I0	..	..	..
c	43	LC I000.0II	..	..	..
d	44	LC I0I0.I00	..	..	..
(	45	LC I000.I0I	..	..	..
	46	LC I000.II0	..	..	..
g	47	LC I0I0.III	..	..	..
h	50	LC I0II.000	..	..	..
i	51	LC I00I.00I	..	..	..
j	52	LC I00I.0I0	..	..	..
k	53	LC I0II.0II	..	..	..
l	54	LC I00I.I00	..	..	..
m	55	LC I0II.I0I	..	..	..
n	56	LC I0II.II0	..	..	..
o	57	LC I00I.III	..	..	..
p	60	LC III0.G00	..	..	..
q	61	LC II00.00I	..	..	..
r	62	LC II00.0I0	..	..	..
s	63	LC III0.0II	..	..	..
t	64	LC II00.I00	..	..	..
u	65	LC III0.I0I	..	..	..
)	66	LC III0.II0	..	..	..
"	67	LC II00.III	..	..	..
x	70	LC II0I.000	..	..	..
y	71	LC IIII.00I	..	..	..
z	72	LC IIII.0I0	..	..	..
(Unassigned)	73	LC II0I.0II	..	..	..
(Unassigned)	74	LC IIII.I00	..	..	..
(Unassigned)	75	LC II0I.I0I	..	..	..
(Unassigned)	76	LC II0I.II0	..	..	..
Erase	77	** IIII.III	** II.III	..	..

Notes

** : This paper tape character appears in both paper tape shifts.

(Unassigned) : There is no printing symbol corresponding to this internal code character.

Lower case letters : The outer set letters a-z are treated as inner set letters A-Z : For the Anelex printer, the card punch and the 5 - channel Teletype.

Carriage Control Characters

Internal Code (octal)	Effect on printed output (see also 8.7.1)
00	None
01	1 line feed without carriage return
02	2 line feeds without carriage return
03	3 .. ..
04	4 .. ..
05	5 .. ..
06	6 .. ..
07	7 .. ..
10	8 .. ..
11	9 .. ..
12	10 .. ..
13	11 .. ..
14	12 .. ..
15	13 .. ..
16	14 .. ..
17	15 .. ..
20	Carriage return without line feeding
21	1 line feed with carriage return
22	2 line feeds with carriage return
23	3 .. ..
24	4 .. ..
25	5 .. ..
26	6 .. ..
27	7 .. ..
30	8 .. ..
31	9 .. ..
32	10 .. ..
33	11 .. ..
34	12 .. ..
35	13 .. ..
36	14 .. ..
37	15 .. ..

Carriage Control Characters (continued)

Internal code (octal)	Effect on printer (see also 8.7.1)
40	Paper Feed without carriage return: home on channel 0
41	 1
42	 2
43	 3
44	 4
45	 5
46	 6
47	 7
50	Paper Feed with carriage return: home on channel 0
51	 1
52	 2
53	 3
54	 4
55	 5
56	 6
57	 7
60	None on existing equipments
61	.. ..
62	.. ..
63	.. ..
64	.. ..
65	.. ..
66	.. ..
67	.. ..
70	.. ..
71	.. ..
72	.. ..
73	.. ..
74	.. ..
75	.. ..
76	.. ..
77	.. ..

8.7.3. The FORTRAN Card Code

The twelve card rows are divided into an upper curtate of three rows, the +, - and 0 rows, and a lower curtate of 9 rows, numbered I - 9. Each character is represented by at most one hole in the upper curtate and at most two holes in the lower curtate of a column. If two holes are punched in the lower curtate one of these must be in the '8' row. The characters are divided into four groups or 'zones', depending on the upper curtate punching; no zone, where no hole is punched in the upper curtate, and the +, - and 0 zones where a hole is punched in the +, - and 0 rows respectively.

The table below gives the relation between a character punched on a card, its printed representation and its internal representation. On input if a character which is in the table below is read it is given the internal representation shown. Any characters read which are not listed below e.g. 8,9; +,I,8, are represented by the fault character 77. On output any internal character which has no equivalent punched character in the table below is replaced by internal character 77 and punched as +,3,8, printed as '.' (full stop).

No Zone

Holes punched	Printed as	Internal Character Octal
None	Space	0I-I
I	I	2I-I
2	2	22-I
3	3	23-I
4	4	24-I
5	5	25-I
6	6	26-I
7	7	27-I
8	8	30-I
9	9	3I-I
3,8	=	34-I
4,8	'	40-I
5,8	&	I5-I
6,8	:	I7-0

+ Zone

Holes punched	Printed as	Internal Character Octal
+	+	35-I
+,I	A	4I-I
+,2	B	42-I
+,3	C	43-I
+,4	D	44-I
+,5	E	45-I
+,6	F	46-I
+,7	G	47-I
+,8	H	50-I
+,9	I	5I-I
+,3,8	.	37-I
+,4,8	)	II-I
+,5,8	>	33-I
+,6,8	_ (underline)	26-0
+,7,8	| (vertical line)	27-0

- Zone

Holes punched	Printed as	Internal Character Octal
-	-	36-I
-,I	J	52-I
-,2	K	53-I
-,3	L	54-I
-,4	M	55-I
-,5	N	56-I
-,6	O	57-I
-,7	P	60-I
-,8	Q	6I-I
-,9	R	62-I
-,3,8	π	I3-I
-,4,8	*	I6-I
-,5,8	?	I4-I
-,6,8	]	22-0
-,7,8	[	2I-0

0 Zone

Holes punched	Printed as	Internal Character Octal
0	0	20-I
0,I	/	I7-I
0,2	S	63-I
0,3	T	64-I
0,4	U	65-I
0,5	V	66-I
0,6	W	67-I
0,7	X	70-I
0,8	Y	7I-I
0,9	Z	72-I
0,3,8	,	I2-I
0,4,8	(	I0-I
0,5,8	<	32-I

8.7.4 The Flexowriter Code

In general the inner and outer set representations of an internal computer character correspond to the upper and lower case printing respectively of a character on the tape. In the following table each computer character is marked with either 'I' to indicate an inner set or 'O' to indicate an outer set character or 'CC' to indicate a carriage control character. All tape characters should have an odd number of holes in the tape. Those which have not will be replaced by the '77' (Fault) character in the computer.

Two of the keys and the corresponding paper tape characters have alternative printed symbols on some Flexowriters. Thus the key which punches the character OIOI.OIO gives either

α on upper case and ^{2} (superscript 2) on lower case or
IO on upper case and % (percent) on lower case.

Similarly the character OIII.OII gives either

β on upper case and π (pi) on lower case or
II on upper case and £ on lower case.

It is not possible on input for the computer to differentiate between the alternative meanings for these characters on the paper tape and hence the former punched character will always be given the Internal Code of 32-Outer Set (α) or 30-Outer Set (^{2} superscript 2) and the latter character will always be given the Internal Code of 33-Outer Set (β) or I3-I(π) on upper case and lower case respectively. Conversely for output on a seven-channel paper tape punch the Internal Code representations for IO,% , II and £ are treated asnon-admissible.

Character on tape	Upper Case printing	Lower Case printing	Internal Character octal	
OOIO.OOO		Space	OI	
OOOO.OOI			OO	
OOOO.OIO		Newline	2I-CC	
OOIO.OII		Paper Throw	40-CC	
OOOO.IOO		Tabulate	02-I	
OOIO.IOI		Backspace	03-I	
OOIO.IIO		Lower Case	06	
OOOO.III		Upper Case	07	
OOOI.OOO			I0-0	
OOII.OOI			II-0	
OOII.OIO			I2-0	
OOOI.OII			I3-0	
OOII.IOO		Stop	I4-0	
OOOI.IOI		Punch On	I5-0	
OOOI.IIO		Punch Off	I6-0	
OOII.III	/	:	I7-I	I7-0
OIOO.OOO	0	.	20-I	40-I
OIIO.OOI	I	[	2I-I	2I-0
OIIO.OIO	2	]	22-I	22-0
OIOO.OII	3	<	23-I	33-I
OIIO.IOO	4	>	24-I	33-I
OIOO.IOI	5	=	25-I	34-I
OIOO.IIO	6		26-I	26-0
OIIO.III	7	¯	27-I	27-0
OIII.OOO	8	(	30-I	I0-I
OIOI.OOI	9	)	3I-I	II-I
OIOI.OIO	α (I0)	^{2}(superscript 2) (%)	32-0	30-0
OIII.OII	β (II)	π(£)	33-0	I3-I
OIOI.IOO	½	?	34-0	I4-I
OIII.IOI	+	&	35-I	I5-I
OIII.IIO	-	*	36-I	I6-I
OIOI.III	.	,	37-I	I2-I

8.7.4 Continued

Character on tape	Upper Case printing	Lower Case printing	Internal Character Octal
I000.000			37-0(U.C.) 40-0(L.C.)
I0I0.00I	A	a	4I
I0I0.0I0	B	b	42
I000.0II	C	c	43
I0I0.I00	D	d	44
I000.I0I	E	e	45
I000.II0	F	f	46
I0I0.III	G	g	47
I0II.000	H	h	50
I00I.00I	I	i	5I
I00I.0I0	J	j	52
I0II.0II	K	k	53
I00I.I00	L	l	54
I0II.I0I	M	m	55
I0II.II0	N	n	56
I00I.III	O	p	57
III0.000	P	p	60
II00.00I	Q	q	6I
II00.0I0	R	r	62
III0.0II	S	s	63
II00.I00	T	t	64
III0.I0I	U	u	65
III0.II0	V	v	66
II00.III	W	w	67
II0I.000	X	x	70
IIII.00I	Y	y	7I
IIII.0I0	Z	z	72
II0I.0II			73
IIII.I00			74
II0I.I0I			75
II0I.II0			76
IIII.III	Erase		77-0

8.7.5 The Five Channel Paper Tape Code

Three of the keys when on figure shift and one of the keys when on letter shift, and the corresponding paper tape characters, have alternative printed symbols on some Creed teleprinters. Thus

(i) 00.110 on figure shift has the alternative printed symbols of ≒ (curly equals) and v
(ii) 00.011 on figure shift has the alternative printed symbols of ø (phi) and x
(iii) 10.111 on figure shift has the alternative printed symbols of ' (apostrophe) and n

and

(iv) 01.111 on letter shift has the alternative printed symbols of π and £ .

The former symbol in each case is a Mercury Autocode character and the latter symbol is the standard Mercury/Pegasus/Sirius character.

On input the computer assigns the Internal Code value corresponding to the Mercury Autocode symbol i.e. ≒, ø, ', and π . On output for five-channel paper tape the Internal Code representations for v, x, n and £ are treated as non-admissible.

Character	Character Printed		Internal Character
	Letter Shift	Figure Shift	
00.000	Figure Shift		07
10.000	A	1	41-I 22-I
01.000	B	2	42-I 22-I
11.000	C	*	43-I 16-I
00.100	D	4	44-I 24-I
10.100	E	(	45-I 10-I
01.100	F	)	46-I 11-I
01.100	G	7	47-I 27-I
00.010	H	8	50-I 30-I
10.010	I	≠	51-I 25-0
01.010	J	=	52-I 34-I
11.010	K	- (minus)	53-I 36-I
00.110	L	≒(curly equals)(v)	54-I 31-0
10.110	M	LF	55-I 01-CC
01.110	N	Space	56-I 01
11.110	O	,	57-I 12-I
00.001	P	0	60-I 20-I
10.001	Q	>	61-I 33-I
01.001	R	≥	62-I 24-0
11.001	S	3	63-I 23-I
00.101	T	->	64-I 23-0
10.101	U	5	65-I 25-I
01.101	V	6	66-I 26-I
11.101	W	/	67-I 17-I
00.011	X	ø(phi)(x)	70-I 20-0
10.011	Y	9	71-I 31-I
01.011	Z	+	72-I 35-I
11.011	Letter Shift		06
00.111	.	.	37-I
10.111	?	'(apostrophe)(n)	14-I 40-I
01.111	π (£)	C.R.	13-I 20-CC
11.111	Erase		77-0

8.7.6 The Teleprinter Code

The teleprinter can only be used by the Supervisor and Test programs. When the output is in Internal Code the code conversion used is that for the teletype punch. Hence the correct printing is obtained only if a restricted set of characters is used.

Octal Value (Digits 35-27)	Internal Code (octal)	Printed Character	Octal Value (Digits 35-27)	Internal Code (octal)	Printed Character
100	01	SP (space)	400	37-0	,(comma)
004	00	* (asterisk)	504	41-I	a
010	21-CC	NL (newline)	510	42-I	b
114	40-CC	(red)	414	43-I	c
020	02	(black)	520	44-I	d
124	03	π (pi)	424	45-I	e
130	06	] 43	430	46-I	f
034	07	[	534	47-I	g
040	10-0	(	540	50-I	h
144	11-0	)	444	51-I	i
150	12-0	<	450	52-I	j
054	13-0	>	554	53-I	k
160	14-0	:	460	54-I	l
064	15-0	_ (underline)	5564	55-I	m
070	16-0	| (vertical bar)	570	56-I	n
174	17-01	/ (oblique stroke)	474	57-I	o
200	20-I	0	700	60-I	p
304	21-I	1	604	61-I	q
310	22-I	2	610	62-I	r
214	23-I	3	714	63-I	s
320	24-I	4	620	64-I	t
224	25-I	5	724	65-I	u
230	26-I	6	730	66-I	v
334	27-I	7	634	67-I	w
340	30-I	8	640	70-I	x
244	31-I	9	744	71-I	y
250	32-0	α (alpha)	750	72-I	z
354	33-0	β (beta)	654	73	?
260	34-0	½	760	74	=
364	35-I	+	664	75	' (prime)
370	36-I	-	670	76	& (and)
274	37-I	. (point)	774	77-0	ER (erase)

8.8 I.B.M. Magnetic Tape

8.8.1 Tape Layout and Specification

8.8.1.1 The tape is $\frac{1}{2}$" wide and has 7 tracks. Of these 7 tracks 6 are used for data and 1 for parity. There is no clock track provided and characters are recognised by the presence of bits in at least one of the tracks. Two densities of recording are possible, 200 and 555 characters/inch.

8.8.1.2 Information is recorded using the NZRI (non return to Zero, IBM) method i.e. the tape is saturated in either of two possible directions. A one is recorded on the tape by a reversal of flux whilst a zero is the absence of such a reversal.

8.8.1.3 Data is written in two different character representations. They are:

a) Binary mode

When it is desirable to use magnetic tape as a backing store to the computer the data will be transferred to tape directly from the main store without any code conversion and hence will be in straight binary form. In the Binary mode the parity bit is such that the number of bits in a stripe is odd.

b) BCD Mode

If, however, the magnetic tape is considered as an output device then alpha-numeric information will be required. The data must therefore be coded and is (known as being) written in the BCD or Binary Coded Decimal Mode. In the BCD mode the parity bit is such that the number of bits in a stripe is even.

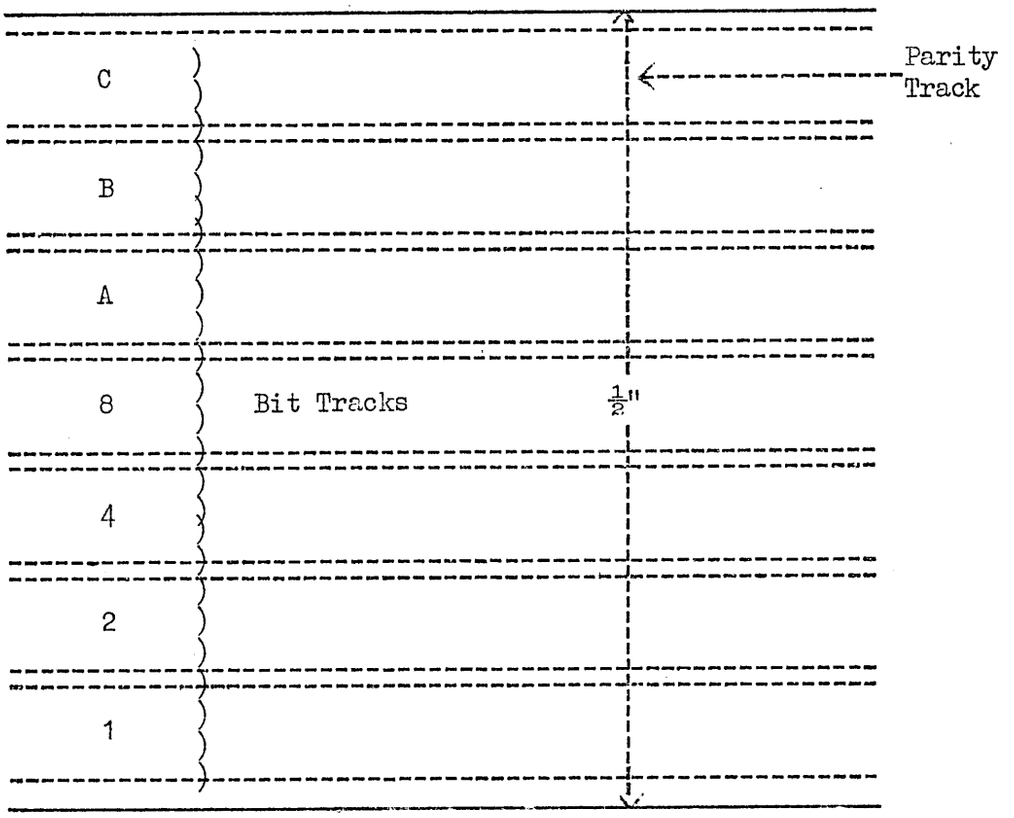
8.8.1.4 Blocks of data on tape, known as RECORDS, can in theory be any length and are unaddressed. Because records are of variable length selective overwriting is virtually impossible.

8.8.1.5 After each record is written a check character, known as the Longitudinal Redundancy Check Character or LRCC. The character is such that the number of ones in the record, including these in the character itself, in each of the 7 tracks, is even.

The check is a bi-product of the method of recording. As stated in paragraph 1.2 ones are recorded by reversals of flux due to reversals of current in the writing heads. At the end of a record the current in each head is returned to the initial direction, a one being written wherever the direction of current in a head is switched over.

8.8.1.6 In order that tape wastage should be as little as possible the inter-record gap is 3/4". For compatibility between all IBM tape units this gap length should be kept as accurate as possible.

C Bit Track Closest to Tape Unit



8.8.2 The I.B.M. 729 IV Tape Unit

8.8.2.1 Performance

Tape speed is 112.5 ins/sec. The character transfer rates are therefore 22.5 and 62.5 Ko/s when the recording densities are 200 and 555 characters/in respectively.

8.8.2.2 729 IV Tape Units have separate read and write heads. This allows the data written on tape to be checked for accuracy immediately after writing.

The Interhead gap is .300 inches (or 2.67 ms at nominal tape speed).

8.8.2.3 Writing on Tape

The current in the write head is always left on when writing on a tape. This is done to avoid depositing noise in the inter-record gap when switching the current on and off and also to erase any previous information written in the present inter-record gap (as a consequence of writing variable length blocks the inter-record gap is not likely to occur in the same place). This feature is not usually troublesome; however, special measures do have to be taken when Backspacing the tape (see below).

8.8.2.4 Backspacing a Tape

It is not possible to write or read a tape backwards but it is possible to backspace the tape a record at a time. To avoid erasing a tape while Backspacing the tape can only be moved backwards when the tape unit is in the Read Status i.e. with the write current switched off. Special action is taken if a Backspace order is attempted while the tape unit is in the Write Status (the write current switched on). In this case the tape is moved forward a distance slightly greater than the inter-record gap while still in write status. This action leaves a clean inter-record gap after the record. Write status is dropped and the noise bits, written on tape, are well clear of the preceeding record and in a position where they will be removed should further records be written on this tape. The backspace operation then proceeds in the normal way, i.e. the tape is moved backwards until the beginning of the record is reached and tape motion is stopped at a time which will ensure that a Re-read or Re-write operation will be obeyed satisfactorily. (Tape drive is switched off 3ms after the beginning of the record is detected). Logic is built into the tape units to prevent a backspace operation being carried out if the tape is at the Load point.

8.8.2.5 Rewinding Tape

To avoid erasing the tape it can only be rewound when the tape unit is in the Read Status. If an attempt is made to rewind in the Write Status a similar procedure is adopted to that for an attempted Backspace order when in the write status (see paragraph 2.4). The tape is moved forward in the write status a distance greater than the inter-record gap. Read status is picked up and the tape rewound.

For full details of control and operation of IBM 729 IV tape units see IBM 729-II and 729-IV Magnetic Tape Units, Technical Information for Original Equipment Manufacturers; and also 729-II, 729-III, 729-IV Magnetic Tape Units, IBM Customer Engineering Manual of Instruction.

8.8.3 General Description of the System

8.8.3.1 General

The Control Unit organises the transfer of data between IBM 729 IV Tape Units and the Atlas Core Store and it is considered as a fast Atlas peripheral device. Associated with the unit there is a small buffer store. Transfers between Atlas and this buffer are organised by a fixed store program. The program is called in on an interrupt basis whenever the control unit signals by means of a Look-at-Me that the transfer is complete.

The buffer is made up of two registers V and A each 4 x 24 bits long.

8.8.3.2 Basic Description of Tape Control Unit Performance

8.8.3.2.1 Orders that can be obeyed by the Control Unit

(i) Read-transfer the next record from tape to Atlas

(ii) Write-transfer the next record from Atlas to tape

(iii) Backspace - move the tape backwards one record

(iv) Rewind - rewind the tape to the load point

(v) Rewind and unload - as (iv) except that the tape unit is also unloaded.

(vi) Skip to file - move on until next file marker is read.

8.8.3.2.2 Transfers may be in any combination of High/Low Density and Binary/BCD mode, or odd/even parity.

8.8.3.2.3 The Tape Control logic consists of one read/write channel such that only one of the orders Read, Write, Backspace, or Disengage may be in progress at any one time. However Rewind if previously initiated may be in progress simultaneously on other tape units.

8.8.3.2.4 Up to six IBM 729 MK. IV tape machines may be connected to the tape control logic.

8.8.3.2.5 Character conversion will be done in the BCD mode for both read and write transfers.

8.8.3.3 General Description of the Logic

8.8.3.3.1 When reading data from tape

Characters are received in seven read flip-flops known as Read Stats, staticisation being essential to accommodate any tape skew within each character. The characters are then gated to successive six bits of register A (the parity digit is not transferred to the buffer). When A is full the data is transferred to V and BIMI is set. In due course the interrupt is dealt with and the data in V is read to Atlas.

8.8.3.3.2 When writing data to tape

The data is written to V from Atlas during the period while the data in A is being dealt with. When A has been emptied the new data held in V is transferred to A and BIMI is set to indicate to Atlas that V needs refilling. The data in A is extracted 6 bits at a time and written on tape via 7 write stats, one extra digit being added to give the character the correct parity.

8.8.4 Specification of Lines between the Tape Control Unit and Peripheral Co-ordinator

8.8.4.1 Layout of Tape Control V-store

Type 5

Line 0 *600412

Digit	Direction	Name
24-26	RW1	No. of odd characters. N.B. 000 means 8 characters address of last word accessed in core store
27-35		
36	R	DISENGAGED
	W	READ
37	R	LONGITUDINAL PARITY
	W	WRITE
38	R	LATERAL PARITY
	W	BACKSPACE
39	R	MECHANICAL FAILURE
	W	REWIND
40	R	TAPE INDICATOR (end of tape detected during write operations only)
	W	REWIND LOAD
41	R	LOAD POINT (beginning of tape)
	W	LONG GAP
42	R	LOW DENSITY
	W	LOW DENSITY
43	R	BCD MODE
	W	BCD MODE
44	R	REWINDING (implies disengaged)
	W	RECOVER READ
45	R	FILE MARK READ
	W	SKIP TO FILE MARK
46	W	EVEN PARITY
47	W	POLAM
	R	INVERSE LAM (0 if LAM)

TYPE 5

Line 1 *6004121

Digit	Direction	Name
24-26	W	SELECT TAPE UNITS 1 - 6

Type 15

Line 8 *60043700

Digit	Direction	Name
31	R	I.B.M. Magnetic Tape, End of Operation

8.8.4.2 Description of V-store

Titles of each digit are followed by Atlas Reference Name and Tape Control waveform name.

I.B.M. Magnetic Tape, End of Operation (Type 5 Line 0 Digit 47) (ELMI)

This is set by the Control Unit at the end of each operation as follows:-

(a) Read After LRCC has been read and last buffer transfer completed.

(b) Write After LRCC has been read back and checked

(c) Backspace 3 ms after the last character of the block has been detected.

(d) Rewind, Disengage, Rewind and Disengage When a relay closure return signal operates in the tape unit (10 ms).

(e) When the selected tape unit does not respond to control signals of an order. Mechanical failure is also set.

(f) When a tape unit is Disengaged manually whilst obeying an order.

End of Operation Look-at-Me indicates that the previous operation is complete so far as the Tape Control Unit is concerned, and that the next order may proceed.

Character Count (Type 5 Line 0 Digits 24-26) (V10/24-27)

(a) Read Set by Tape Control to indicate the number of significant characters in the last word of a Read Operation. Zero in the count indicates that the last word is full.

(b) Write Set by Write extracode, to indicate the number of significant characters in the last word. Zero in the count indicates that last word is full.

Select BCD Mode (Type 5 Line 0 Digit 43) (VIC)

When set this digit causes future transfers associated with the present order to be carries out in the BCD mode. If this digit is not set transfers will be carried out in the binary mode.

Select Low Density (Type 5 Line 0 Digit 42) (VISL)

When set this digit causes information associated with the present order to be recorded on tape at low density. If this digit is not set information will be recorded at high density.

This digit must also be set when reading information, which is recorded at low density, from tape.

Select Tape Unit 1-3 (Type 5 Line 1 Digit 24-26) (U11-U13)

The unit remains selected until a further unit is selected. When the control unit is switched on (as in the norming) TU0 is automatically selected (TU0 is engineer's TU).

Low density selected and BCD selected (Type 5 Line 0 Digits 42,43)

These allow the supervisor to check that the two flip-flops have been set correctly.

Recover Read (Type 5 Line 0 Digit 44) (VIT)

If during a normal read operation a parity failure occurs a further attempt may be made to read a record by using a reduced bias level in the peak sensers. The reduced bias level is selected by Recover Read Digit.

Read Order (Type 5 Line 0 Digit 36) (RI)

An order digit which causes a Read operation to be performed on the selected tape unit, when it is set.

Write Order (Type 5 Line 1 Digit 37) (WI)

As above except for Write.

Backspace Order (Type 5 Line 0 Digit 38) (BI)

An order digit, which, when set causes the selected tape unit to move backward one record.

Rewind Order (Type 5 Line 0 Digit 39) (VIN)

An order digit, which, when set causes the selected tape unit to rewind to the Load Point.

Rewind and Disengage Order (Type 5 Line 0 Digit 40) (VIND)

As above except that the tape unit is disengaged and the tape rewound until the Load Point is reached.

Mechanical Failure (Type 5 Line 0 Digit 39) (FIM)

Set up by the Tape Control Unit as follows:-

(i) When the selected tape unit does not respond to the initial control signals of an order. In this case execution of the order is inhibited and ELMI is set.

(ii) When the selected tape unit is disengaged manually whilst it is obeying an order. ELMI is also set.

(iii) During a Write order when a Write Echo failure occurs.
Tape Unit 1-3 Disengaged (Type 5 Line 0 Digits 28-30) (RPIEU1-3)

Set to one while a tape unit is disengaged. A tape unit may be disengaged by a Disengage order from Atlas or by pressing the 'Reset' key on the tape unit. A tape unit may be engaged only if the deck is loaded with all interlocks closed and the 'Start' key has been pressed.

Rewind in Progress Tape Unit selected (Type 5 Line 0 Digit 44) (RPINU1-3)

Set to one while a Rewind order is carried out on the Tape Unit selected.

Lateral Parity Failure (Type 5 Line 0 Digit 38) (PILA)

Set up during a Read, Write or Backspace operation by Tape Control if a lateral parity check failure is detected.

Longitudinal Parity Failure (Type 5 Line 0 Digit 37) (PILO)

As above, except for longitudinal parity failure.

Tape Indicator (Type 5 Line 0 Digit 40) (RPIIND)

Set by tape unit when the reflective spot at the end of tape is photosensed. Reset by Put Out End of Operation signal.

Load Point Indicator (Type 5 Line 1 Digit 28) (RPILP)

A signal which is in the "one" condition if the tape on the selected tape unit is at the Load Point. When the tape is moved from Load Point position the Load Point Indicator falls to the "zero" condition.

Write Strobes for Input Lines (Logical Design Only) (ITVA-ITVF)

6 input strobes are provided, one for each line of the V-store. These are used to strobe the information set in each digit of the line into the V-store.

These strobes are labelled ITVA-ITVF corresponding to lines 0-5 respectively.

Console Reset (Logical Design Only) (IRC)

A strobe used to reset all stats in the Tape Control Unit to their standard states when the machine is switched on (in the morning, etc.).

8.8.4.3 Lines between Tape Control and the Tape Units

Use is made of the IBM tape unit bus system. In this system all control lines are common to all tape units with the exception of those actually specifying which Tape Unit is selected.

The signals required by these control lines swing about either of two reference levels. These reference levels are:-

(a) N type; whose level is ground and

(b) P type; whose level is -6 volts.

For reliable operation a minimum swing of $\pm$0.4 volts is required but IBM recommend that the swing should be $\pm$ 1 volt. Level changers have been built which convert between standard Atlas signal levels and both N and P type levels.

The standard IBM lines to and from the Tape Units are as follows:-

8.8.4.3.1 Lines to IBM Tape Units

+P Select Waveform Names; UI1, UI2, UI3

Each of these 3 lines is used to select a particular tape unit from the group connected to the common Control Unit. The signal gates the tape unit selected allowing it to receive all subsequent signals from the Control Unit. The line must be held at +P level for the duration of the operation. Dropping the Select Line immediately stops any tape operation except rewind.

+P GO Waveform Name; WPIGO

This line is used to control tape motion. Bringing GO to +P level starts tape motion; whilst Dropping GO stops it except for rewind.

+P Set Read Status Waveform Name; WPISR

When pulsed at +P level for 1 usec. this line switches the Read/Write flip-flop in the selected tape unit to read status (if not already there).

-N Set Write Status Waveform Name; StWI

Same as above except for write

-N Backwards

Waveform Name; ILBK

A line which when held at +N level causes any tape motion to be in the forward direction and when held at -N causes it to be in the backward direction. It must not be changed whilst the GO line is at +P level.

8.8.5. Details of the Control Unit, its operation and Design.

5.1 Timing

The major part of the control unit is synchronised with the character transfers to and from tape. The character transfer rate is of course governed by the recording density and tape speed and is 22.5 Kc/s at Low density and 62.5 Kc/s at High density.

5.1.1 Writing

The character transfer rate is controlled by either of two crystal oscillators dependent on whether the recording density is high or low. For reasons which will appear later it is convenient to use basic oscillator frequencies which are 16 times greater than the character rate, i.e. 360 Kc/s and 1Mc/s.

It is important to point out that the same hardware is used for both densitites, a change of density being merely a change of oscillator.

5.1.2. Reading

The circuitry is controlled by the rate of arrival of characters from the tape itself.

In theory therefore it is unnecessary to know what the density of recording is. However the end of a record is determined by the absence of any characters within a given time. As the time is different for the two recording densities the density of any particular tape, in fact, must be known.

5.2 Buffer Registers

There are 96 bits in each of the two buffer registers, V and A, This number is a compromise between the amount of hardware used in the buffer and the amount of central computer time used dealing with Buffer Attention Interrupts. With a 96 bit buffer 20% of the central computer's time is used in dealing with tape control interrupts when working with long blocks on high density tapes. The general formula for the percentage computer time used for dealing with interrupts is:-

$$\frac{T + q\,n + \left[(n+p-1)/p\right] t}{7300 + 128n} \times 100$$

where T = Terminal computing time (~100/usec)
q = time of loop to transfer one 48 bit Atlas word (between 8 and 14/usec)
n = size of block in words
p = size of buffer in words
t = time to deal with an end of interrupt (~30/usec)
[ ] = means the integral part of

5.2.1. The information flip-flops are numbered lines 2, 3, 4 and 5 digits 24 - 47, digit 47 in line 5 being the most significant. Information is strobed into buffer A from the Read Stats character by character during a Read order, but it is strobed 24 bits at a time from the Peripheral Co-ordinator into V during a Write order. The strobe in the latter case is supplied by the Peripheral Co-ordinator for with the interrupt method of operation the Tape Control Unit has no indication when the Buffer Attention Look At Me will be dealt with.

To reduce the loading on each output of the flip-flops in the registers to one standard load, transfers between the two registers are done by the Reset and Single Sided set technique.

Should a read or write transfer conclude with a partially filled buffer a count indicating the number of significant characters will be sent to or from Atlas respectively.

8.8.5. Continued..

5.3 Significant Character Count and Stop Write Digits

As the number of possible characters in each buffer register is 16, 4 flip-flops are needed for the count. It is convenient to consider the flip-flops as part of the buffer. These digits are referred to as the Significant Character count, VIO digits 24 - 27.

With Write transfers only, a digit must be sent to the tape control unit from Atlas to indicate when the last transfer is taking place. The digit is also considered as part of the buffer and is referred to as the Stop Write Digit, AIO/28.
(No digit is required to indicate the last read transfer as this transfer is accompanied by End of Operation Look at Me).

5.3.1. When Writing

These five extra digits are written to V at the same time as the last characters of a record. They are transferred to A under Transfer Control where the Stop Write Digit is recognised immediately and is used to inhibit setting BLMI.

It also allows comparison between the Significant Character Count and the number held in the Character Counter (para 5.14). As the characters are written on tape the Character Counter is increased and at some count coincidence occurs between the number in the counter and the Significant Character Count. Waveform ICIN is generated which is used by Write Control to terminate Write orders.

5.3.2. When Reading

When the last buffer transfer takes place to V the current character count is transferred to the significant Character Count, VIO digits 24-27, where it is read with the last few characters in the buffer.

Note. All Read and Write Transfers transfer the Significant Character Count between V and A but they are only meaningful when dealing with the last characters of information.

5.4 Write Control

5.4.1 Performance.

The logical design is governed mainly by IBM specification for Writing information. The relevant requirements are that:
(a) The character repetition rate is every 16/usec (44.5)
(b) That the 7 bit stripe should be set up on the Write Bus with as little skew as possible.
(c) That a Write Pulse Line should be pulsed with a 1/usec (2.78) wide pulse. This pulse should not occur before 4.5/usec after the character has been set up on the Write Bus.
(d) That the Write Bus should be cleared 15/usec (41.7) after it is set up.
(e) That the Longitudinal Redundance Check Character should be written 64/usec (178) after the completion of the last Write Pulse.
The figures without brackets refer to High Density and the figures in brackets refer to Low Density.

As the repetition cycle time even at High Density is 16/usec the Write Bus is cleared for 1/usec. which gives adequate time for a new character to be set up on the Write Stats. The LRCC is written by dropping the Write Check Character line (para 4.3.1.) at the correct time. This line is set at the same time as the Write Pulse line is pulsed for the first character.

5.4.2 Logic Design.

From the above required performance it is apparent that a basic frequency of 1 Mc/s (360 Kc/s) will be useful.

The control unit of the Write Control is a 4 bit counter which is fed from either of two crystal oscillators. These oscillators produce 100 m/usec pulses every 1/usec (2.78). The counter is decoded to give the necessary timing required during the write cycle.

8.8.5 Continued..

The decoded waveforms are gated with the crystal oscillator to give 100 m/usec pulses.

The Write Stats are connected directly to the Write Bus so that Information is set up on the Write Bus by setting the Stats and is cleared from the Bus by resetting them.

The general sequence of events is:

(i) Set character on Write Bus.
(ii) add one to counter.
(iii) test if zero.

A consequence of this layout is that zero in the Significant Character Count represents a full buffer.

5.4.3 Operation

After completion of the WRITE DELAY, which allows the tape to get up to a speed and also defines the length of the interecord gap, waveform ILWRA occurs (para 5.7.5). This waveform gates one of the crystal oscillators to the Write Counter. Flip flop WRI is used to clean up the oscillator pulse if it should occur at the same time as ILWRA. Only 4 bits of this counter are relevant initially.

The 100 m/usec pulse waveforms StITWS(mo), ITWKA (M7), ITWTA (m8), StIRWS (m15) are generated cyclically; the timing of these waveforms is given in brackets.

StITWS strobes the character selected by the current character count from Buffer A to the Write Stats (para. 5.18) and hence to the Write Bus (para. 4.3.1)

ITWKA Sets stat. WPIWP switching the Write Pulse line on (para. 4.3.1.)
adds one to the Character Counter (para. 5.14)
sets Write Echo Stat. WIWE.
sets stat. WPILRCC switching the Write Check Character line (para. 4.3.1.) to the 'on' state at the same time as the first Write Pulse.

ITWTA resets WPIWP switching the Write Pulse line off.
tests whether a buffer transfer is required (para 5.6.1.).

StIRWS resets the Write Stats (para 5.18)
/1 & 2 tests that WIWE ahs been reset by a Write Echo pulse, RPIWE, (Para 4.3.2). If WIWE has not been reset then the Mechanical Failure digit is set (paras 4.2 and 5.7.2.1.)

When ICIN (para 5.3.1.) occurs the counter is extended by 3 stages. The waveform occurs after m7 because the Character Counter is advanced then but well before m15. The counter now becomes modulo 128 instead of modulo 16, so that after the last character has been written on tape m0, m7, m8 and m15, and their corresponding waveforms are logically inhibited.

When the counter reaches m72 (m8 + 64) StITCW is generated which resets the Write Check Character stat and inhibits further counting.

5.5 Read Control

The general sequence of events is (i) Detect Character
(ii) Add one to counter
(iii) test if zero

A character in the Read Stats (para 5.19) is detected by mixing the outputs of the stats together. Read control accepts the character provided that the last character of the record has not so far been detected. The Longitudinal Redundancy Check Character is rejected by gating with ILRCCD. The pulse generated is delayed by 7.0/usec at High or 20.0./usec at Low Density to allow the whole character to be set up even in cases of serious tape skew.

8.8.5 Continued..

The sequence of events is then as follows:-

ITCB is sent to the Longitudinal Parity Logic where the bits of the character including parity, held in the Read Stats, are 'non equivalently' added into the Longitudinal Parity Register (para. 5.16)

StITL/3 and via this logic to the Record Gate Logic (para 5.13)

ITCB sets the 'Lateral Parity Failure stat, PILA, if the number of ones in the character held in the Read Stats. is inconsistent with the mode of recording (para 5.15.)

ITCA gates the character away to buffer A if the a Read order is being obeyed (see ED/A/19.1D)

ITCB resets the End of Blank Tape Stat, INDIA, (para 5.10) if this stat has been set by the Tape Indicator

0.5/us later

ITCC advances the Character Counter by one (para 5.14)

0.5/us later

ITCD tests if a buffer transfer is required (para 5.6.1.)

StIRRS resets the Read Stats in preparation for the arrival of the next tape character (para 5.19)

5.6 Transfer Control

5.6.1. Normal Operation

Any transfer which is not the first or the last in a record is considered as normal in this context. After every character has been read by Read Control or written by Write Control a signal (para 5.4.3. and 5.5) is sent to Transfer Control to test whether a buffer transfer is required. This is so if the character count is 16 i.e. waveform StISC00 is operative (para. 5.14).

Firstly a check is made to ensure that Buffer Attention Look at Me, BLMI, set by the previous transfer, has been reset by Atlas. If it has not then the Overdue Digit, OIBLM, is set.

The transfer sequences for Read and Write orders are as follows:-

READ:-	RESET V	TRANSFER A to V	RESET A
WRITE:-	RESET A	TRANSFER V to A	RESET V

Lastly BLMI is set to inform Atlas that Register V needs attention.

5.6.2 Special Operation

Special cases may occur at the beginning and end of a record.

5.6.2.1. First Read Transfers:- The initial characters are dealt with in the normal way as described above.

5.6.2.2 First Write Transfer:- Waveform ITWS from MAIN Control (para.5.7.5.1) sets flip-flop WIS. and also BLMI (It also causes buffer transfers but these are irrelevant). BLMI is detected by an interrupt routine; data is fed to V and BLMI is put out by IRBLM. IRBLM also inspects whether WIS is set. If it is, as in this case, a transfer, V to A, is executed and BLMI is set again. In time the interrupt will be dealt with and V will be refilled.

After the Write Delay ITWRA (para 5.7.5) tests BLMI to make sure that both these transfers have been completed. If these have not been done OIBLM is set.

Transfers then follow the normal pattern.

5.6.2.3 Last Read Transfer:- When dealing with the last read transfer there are two possibilities:

(a) The characters exactly fill a buffer register (i.e. the current character count is 16). In this case ITCD from Read Control (para 5.5) will initiate a Normal Transfer before the Record Gate Logic has determined that characters are in fact the last in the record.

8.8.5 Continued..

Eventually the Record Gate Logic will determine that the end of the record has been reached and READ DISCONNECT, StITRD, PULSE (para. 5.13.1.1) will be sent to Transfer Control.

(b) The characters only partially fill a buffer register. The final ITCD waveform (para 5.5) will find that a buffer transfer is not required and these odd characters will remain in A until StITRD (para 5.13.1.1) arrives.

When the StITRD does arrive the action taken depends on whether or not BLMI is set.

BLMI is set:- The pulse is held up on flip flip RIE until BLMI is reset, the BLMI Not set condition is then obeyed.

BLMI is not set:- The final read transfer is performed and END OF READ SIGNAL, IERD, is generated.

NOTE. When dealing with data which exactly fills the buffer the last read transfer still takes place but is redundant. The interrupt routine dealing with End of Operation has been designed to ignore this transfer.

5.6.2.4. Last Write Transfer:- The final characters are transferred in the normal way as described in para 5.6.1 except that the Stop Write digit, AIO/28, is detected immediately the transfer has taken place and inhibits ITDD from setting BLMI. AIO/28 is also used to inhibit ITWTA whilst writing the last characters. This is necessary for if the number of characters in the buffer happens to be 16 a further transfer would be initiated. This transfer would fill buffer A with 'zeros' and in particular set AIO/28 to zero. ITTD would then be able to set BLMI and so cause a misleading interrupt.

5.7 Control Control

5.7.1 Detect Order

At any time an order may be sent to the Tape Control Unit V store. The presence of this order is detected by mixing all possible order lines together. Waveform ILDO is produced when an order is detected.

5.7.2 To Check that the Order can be obeyed

5 μs are allowed for all the necessary details about the order to be set up on the V store control flip-flops and lines from the selected tape unit to respond to the Select Signal. A test is then made to ascertain whether the selected tape unit is in a position to obey this order. All orders require that the selected unit is READY (para. 4.3.2) and in particular Read and Write orders require that the tape unit is in the Read and Write Statuses (para. 4.3.2) respectively.

If the test is successful then the order digits are transferred by StITSO to a second bank of stats from which the order specified is obeyed. If however the test is unsuccessful the digits are not transferred and ELMI and the Mechanical Failure Digit FIM are set by ITS.

5.7.2.1. The Mechanical Failure Stat (FIM)

The stat is set by:

(a) by ITDO gated with ILS when a tape unit fails to respond to the initial control signals to it (para 5.7.2). ELMI is also set.

(b) by RPIS gated with ILOO if the tape unit is disengaged manually after the order has been initiated. A tape unit may be disengaged at the tape unit by pressing the 'Reset' key or by any major failure occurring such as a tape break.. ELMI is also set.

(c) by IRGWD gated with ILGW 3ms after IRGW is generated (para 5.7.5.2). ILGW is inhibited by ELMI.

This piece of logic is used during a Write Order, to set ELMI and FIM if ELMI is not set by the Record Gate Logic as it is when the system is working correctly.

The Record Gate Logic will not generate StITRD (used to set ELMI) if the logic is never given any characters from Read Control. This will occur if the Reading Circuits in either the Tape Unit or Tape Control fail or if Write Circuits in the Tape Unit fail.

(d) by StIRWS/2 gated with WIWE if a Write Echo failure occurs (para. 5.4.3). In this case ELMI is <u>not</u> set.

5.7.3 The possible orders available are READ, WRITE, BACKSPACE, REWIND, REWIND AND DISENGAGE, and DISENGAGE (see para 4.2). These orders are setup in V store line VI1, digits 24-30. If the order can be obeyed it is transferred to line AI1 by StITSO (para 5.7.2)

8.8.5. Continued..

5.7.4 Read

5.7.4.1 Start

Operation is held by ISFI = until any delay to starting tape motion in the forward direction is complete (para 5.9). ITG sets the GO flip flop. After a delay of 3 or 16 ms. according to whether the tape is not or is at the Load Point information may be read from the tape to the Read Stats (para 5.19) StILRS allows information to enter the Stats. This delay referred to as the READ DELAY is introduced to avoid reading any unwanted noise that may be written in the interecord gaps on tape. StILRS remains open until ILRS stat is reset by Read Disconnect Pulse, StITRD.

5.7.4.2 Finish

The Record Gate Pulse, ITRG, (para 5.13.1) is generated by the Record Gate Logic after the last character of a block has been read but before the LRCC is read. ITRG is used to reset the GO flip-flop (para 5.8) and also to set the ILRCC stat. ILRCCD is used to inhibit reading the Longitudinal Redundance Check Character by ReadControl (para 5.5). The ILRCC stat is not reset until IRELM is received from the Peripheral Co-ordinator. This is done to avoid the LRCC being detected as a spurious character by Read Control at some time later before the Read Stats have been reset.

The read order is terminated by IE RD waveform (para 5.6.2.3) from Transfer Control setting ELMI.

5.7.5 Write

5.7.5.1 Start

Operation is held up by the ISFI= until any delay to starting tape motion in the forward direction is completed (para 5.9). ITG sets the GO flip flop and ITWI puts the first buffer transfer into operation (para 5.6.2.2)

To allow the tape to get up to speed and to define the interecord gap no information is written to tape until 5 or 76 msec afterwards depending on whether the tape is not or is at its Load Point. Writing is initiated by flip flip, ILWRA, the output of which goes to Write Control, and sending ITWRA to Transfer Control to test whether both Buffer Attention interrupts have been dealt with (para 5.6.2.2). At the same time that part of Read Control used to check the data writing on tape is brought into action.

5.7.5.2 Finish

2ms after StITCW is received from Write Control (para 5.4.3) the GO flip-flop is reset by IRGW. StITCW is also used to reset flip-flop ILWRA and so switch off the write counter. StITRD (para 5.13.1.1) generated after the LRCC has been read back and checked, is gated with WRITE to set ELMI.

5.7.6 Backspace

The action on receiving a backspace instruction depends on the Read/Write status of the selected tape unit.

(a) Tape Unit in Read Status:- operation is held up by ISBI until any delay to starting tape motion in the reverse direction is complete (para 5.9). The tape direction stat ILBK, is set to BACKWARDS (para 4.3.1) and the GO flip flop set by ITG. After the READ DELAY (para 5.7.4.1) data may be read from tape to the Read Stats.

Data is read until the Record Gate logic detects the beginning of the record and generates the READ DISCONNECT PULSE, StITRD, (para 5.13.1.2.). The Pulse is gated with BACKSPACE and 3ms later the GO flip flop is reset and ELMI is set by IRGB.

(b) Tape Unit in Write Status:- GO is set by ITBN and reset after 5 ms by ITBNA: during this time the tape will move forward a distance greater than the interecord gap (see para 2.4). The status of the tape unit is switched to READ STATUS by WPISR and a Backspace Operation with the Tape Unit in the Read Status is commenced.

5.7.7 Rewind

The action on receiving a Rewind instruction depends on the Read/ Write status of the selected tape unit.

(a) Tape Unit in Read Status:- START REWIND, WPIN, is sent to the tape unit and after about 10 ms SELECT AND REWIND, RPIN, is returned. This latter signal is gated with WPIN to set ELMI.

(b) Tape Unit in Write Status:- GO is set and reset after 5ms during which time the tape will have moved forward a distance greater than the interecord gap (see para 2.5) The status of the tape unit is switched to READ STATUS by WPISR and a Rewind operation with the Tape Unit in the Read Status is commenced.

The REWIND IN PROGRESS, RPINU, line associated with the particular tape unit is 'on' while the Tape Unit is rewinding. The signal is independent of the tape unit being selected (para. 4.4.2)

5.7.8 Rewind and Disengage

As above except that when the tape unit has completed the rewind the tape is unloaded out of the columns and the tape unit disengages itself from the Tape Control and the Tape Unit Engaged line, RPIEU, falls to the Disengaged level.

5.7.9 Disengage

The Disengage line AID is gated with the selected tape unit to set one of IDU1, IDU2 or IDU3. ELMI is set when the Tape Unit Engaged, RPIEU, line from the selected tape unit falls to the Disengage Level.

5.8 The GO Flip-Flop, WPIGO.

It is set by ITG to start tape motion when obeying Read, Write and Backspace (READ STATUS) and by ITBN when obeying Backspace (WRITE STATUS). However it is only set after any GO Down Time has been completed (para 5.9).

It is reset by various waveforms according to the order being obeyed:-
Write: Reset by IRGW 2ms after WRITE CHECK PULSE, StITCW, (para 5.4.3) has been received by Central Control.
Read: Reset by RECORD GATE PULSE, ITRG, (para 5.13.1.1) gated with READ.
Backspace (READ STATUS): Reset by IRGB 3ms after Read Disconnect Pulse, StITRD, (para 5.13.1.2) has been received by Central Control.
Backspace and Rewind (WRITE STATUS) : Reset by ITBNA 5ms after setting GO.

It is also reset when reading blank tape and the tape indicator is set (para 5.10)

5.9 Minimum Down Time of the GO Flip Flop

5.9.1 Operation

When the tape direction is reversed the Drive Mechanism of the Tape Unit requires 11 ms to change over. Hence the GO line to the particular tape unit should be down for at least 11ms.

In theory information must be held in control about when and what was the last order, requiring tape motion, obeyed by each tape unit before deciding whether a further order involving tape motion can be obeyed immediately. In practise this comprehensive system would require an excessive amount of hardware and so a compromise has been adopted. The normal operation of the tape system is to read or write records and Backspace only to re-read or re-write a record if its parity is incorrect.

The number of sequences of orders which will contain many changes between tape units is likely to be negligible. The compromise adopted is therefore as follows:-

Each time the GO flip-flop is reset, either of two pairs of delays are triggered according to whether the tape direction for the order just completed was Backward or Forward, the outputs of these flip flops are used to inhibit Forward or Backward motion respectively taking place within a further 11 ms. The limitation of the system is that the condition is applied to the Control Unit as a whole and not, as it should be, to each tape unit separately.

Note. The commencement of Backspace and Rewind Orders, when the selected tape unit is in the Write Status, cannot logically be held up because the previous order must have been a Write Order. However with the present system this case is taken into account automatically.

5.9.2 Logic

IRGO, which resets WPIGO, triggers the two pairs of delays according to whether the tape motion is Backward or Forward. The flip flops feed delays totaling 12 ms. 1 ms excess of nominal 11 ms is given to allow for tolerances in the delays. Two delays in series are required because the orders may occur more frequently than 12 ms and a second trigger arriving within this time would be lost in the delay circuit which is an AC coupled monostable flip-flop.

$\overline{\text{ISFI}}$ = controls forward tape motion

$\overline{\text{ISBI}}$ controls backward tape motion.

5.10 End of Blank Tape Logic

If an attempt is made to read a non-existent block the Tape Control Unit will go on searching for the start of the block until the tape is pulled off the spool at its physical end. This logic is designed to prevent this happening by using the Tape Indicator signal RPIIND (para 4.3.2) to stop the tape before its physical end is reached. The logic also informs the Supervisor by setting the End of Operation Look at Me.

The INDIA flip-flop is set by RPIIND provided a Read Order (St RI/1) is being obeyed; that the GO flip-flop is set (WPIGO) and that the Read Stats have been open for 3ms (StILRS, para 5.7.4.1.)

Normally INDIA is reset by ITCB = (para 5.5) when a character is read from the tape or by StITRD if the end of the record has been detected (para 5.13.1.1). If INDIA is still set 3ms after being set it is assumed that the tape being read is blank and tape motion is stopped (para 5.8) and ELMI is set (para 5.11.1.) by INDI.

5.11 End of Operation Look at Me, ELMI

5.11.1 Setting ELMI

Write: Set when the Read Disconnect Pulse, StITRD (para 5.13.1.1) is received from Record Gate Logic.

Read: Set when IERD (para. 6.5.2.3.) is received from Transfer Control.

Backspace: Set 3ms after StITRD (para 5.13.1.2.) is received by Central Control.

Rewind, Rewind and Disengage: Set when RPIN (para 4.3.2) is received from the Tape Unit.

Disengage TU1, TU2, TU3: Set when the RPIEU line of the selected tape unit has fallen to the disengage level (para 5.7.9 and para 4.4.2).

Tape Unit Failure: Set by $\overline{\text{ITS}}$ when a tape unit fails to respond to Control signals (para 5.7.2.1)

End of Blank Tape: Set by INDI (para 5.10) when reading blank tape and the Tape Indicator is set.

8.8.5 Continued...

5.11.2 Resetting ELMI

Reset by IRLM delayed by 1/us. The 1/us delay is included to ensure that all ELMI setting waveforms, also reset by IRELM, have dropped and that the Tape Indicator if set is reset (WPIRIND)

5.12 Reset

Most control flip flops must be reset before a new order can be obeyed. These are reset by IRELM which activates Resetting Strobes StIR/1 - StIR/13. The strobes are also activated by Console Reset, IRC. However IR C is only used when the machine is switched on in the morning.

5.13 Record Gate Logic

5.13.1. Operation

The logic detects the beginning and the end of a record. This is achieved by setting a counter going as soon as the first character is read. The counter is fed from a crystal oscillator with a pulse rate of 1Mc/s at High Density or 360 kc/s at Low Density. Every time a further character is read the counter is reset. When the end of the record is reached no more characters will be read and the counter will build up unchecked. The end of a record is defined by the counter reaching a given value. The actual value depends on the order being obeyed.

5.13.1.1 For Read and Write The RECORD GATE PULSE, ITRG, is generated when the count is 36. As the nominal number of counts between information characters is 16 (16/us High Density, 44.5/us Low Density) the pulse will be generated after the last information character has been read but before the Longitudinal Redundancy Check Character, LRCC, has been read (LRCC is nominally 64 counts after the last information charcter). During a Read Order the RECORD GATE PULSE resets the GO flip flop and so stops tape motion. The READ DISCONNECT PULSE, StITRD, is generated when the count is 144. This value is chosen to ensure that the LRCC has been read.

5.13.1.2 For Backspace When reading tape backwards the first character of a record that is picked up is the LRCC. Obviously it is pointless to stop then. So unlike Read and Write end of Backspace is first detected when the count has reached 144 and the READ DISCONNECT PULSE, StITRD, is then generated.

5.13.2 Logical Design.

Read Control detects a character on tape and sends a READ PULSE, StITL/3 (para 5.5) to the circuit. The pulse is held up on flip flop RG11 until a pulse arrives from the crystal oscillator, IC. RG12 is used to clean up the oscillator pulse if it should unfortunately arrive while RG11 is setting. The cleaned up pulse sets RG13 and resets RG11, RG12, and the Record gate Counter. Once RG13 is set further clock pulses are added into the counter. At High Density 800 m/usec are available for the counter to be reset before the next clock pulse adds into the counter. The counter is switched off by the next READ PULSE resetting RG13; it also sets RG11 and the cycle is repeated until no further READ PULSES arrive. The counter builds up and at counts of 36 and 144 the ITRG and StITRD respectively, are generated for Read and Write orders. For Backspace only the StITRD is generated for reasons given in para. 5.13.1.2.StITRD also resets RG13 and inhibits further counting.

5.14 Character Counter

The counter is used to gate characters into and out of buffer register A. As the buffer holds 16 characters a four stage counter is used. The counter is fed by either ITCC (para 5.5) from Read Control or by ITWKA (para 5.4.3) from Write Control. The output of the counter is decoded on 16 inverters to supply gating for both Read and Write Orders. The 16 waveforms are labelled StISG00 to StISG15, StISG00 is also used to Control entry to Transfer Control (para 5.6.1)

5.15 Lateral Parity Logic

5.15.1 Operation The seventh track of the tape is used to hold a digit which is such that the overall parity is odd if recording is in the Binary Mode, or even if recording is in the BCD Mode.

The required digit is therefore

No. of ones in 6 bit char.	Parity Digit	
	BCD	Binary
EVEN	0	1
ODD	1	0

Writing The parity digit WIBAP is generated from the 6 information digits according to the above table.

Reading The actual parity digit read from tape is compared with the theoretical parity digit generated from the 6 information digits. If these digits are not identical the Lateral Parity Failure digit, PILA, (para 4.2) is set.

5.15.2 Logical Design.

The parity of the six digits is derived by first finding the parities of three sets of two digits using LTPs. The parity is formed of two of these "2 digit" parities and this is combined with the parity of the original 3rd pair to give the parity of the whole.

5.16 Longitudinal Parity Logic

The logic determines whether the number of 'ones' read from each of the seven tape tracks is even or odd. The determination is taken over all the characters of a record except the Longitudinal Redundance Check Character, LRCC, with which it is compared. There should be complete agreement between the two. However, if this is not so the Longitudinal Parity Failure flip flop, PILO, (para 4.2) is set. The logical design is made up of seven independent one digit counters. The counters are known as a whole as the Longitudinal Parity Register. Every time ITCB (para 5.5) is received from Read Control the character currently held in the Read Stats is "added" into the Longitudinal Parity register. The "adding" process amounts to a non-equivalence operation between the character in the Read Stats and the word in the LP register. ITCB does not occur when the LRCC is read to the Read Stats (para 5.5) so that the LRCC is not "added"into the Longitudinal Parity register. However, it is compared with the word held in the register by the READ DISCONNECT PULSE StITRD, (para 5.13.1). If the comparison fails the Longitudinal Parity Failure flip flip PILO (para 4.2) is set.

NOTE It is worth pointing out that although reading backwards is not allowed the parity checks are performed correctly when a Backspace order is carried out.

5.17 BCD Conversion Logic

Information transferred from the Buffer Register A to the Write Stats and from the Read Stats to the Register is, or is not, code converted according to whether the information is recorded in the BCD or Binary Mode.

The conversion logic for the BCD mode allows complete 6 bit to 6 bit character conversion. This general solution was neccessitated because of the considerable difference between the Atlas and IBM internal codes.

The incident characters are decoded to the 64 possiblilities and these are recoded to form the required code converted characters.

5.17.1 The Conversion Code is as follows:-

Atlas Internal	BCD Tape	Atlas Internal	BCD Tape	Atlas Internal	BCD Tape	Atlas Internal	BCD Tape
00	(00)	20	12	40	14	60	47
01	20	21	01	41	61	61	50
02	16	22	02	42	62	62	51
03	17	23	03	43	63	63	22
04	32	24	04	44	64	64	23
05	52	25	05	45	65	65	24
06	36	26	06	46	66	66	25
07	37	27	07	47	67	67	26
10	34	30	10	50	70	70	27
11	74	31	11	51	71	71	30
12	33	32	35	52	41	72	31
13	53	33	75	53	42	73	56
14	55	34	13	54	43	74	57
15	15	35	60	55	44	75	72
16	54	36	40	56	45	76	76
17	21	37	73	57	46	77	77

Note: The character 00 both internally in Atlas and on Magnetic Tape when recording in the BCD mode is an unallowed character but is included in the above table for completeness.

5.18 Write Stats

The Write Stats (WPI1, WP12, WP14, WP18, WPIA, WPIB and WPIC) staticise the character on the Write Bus (para 4.3.1) so that it may be written to the tape by the Write Pulse (para 4.3.1) The stats are set by StITWS at Write Control timing m0 and reset by StIRWS at timing m15 (para 5.4.3).

5.19 Read Stats

Provided StILRS (para 5.7.4.1) is open the Read Stats are connected without gating to the peak sensers and so to the Read Bus (para 4.3.2). Therefore a character read on the selected tape unit is set up, as it appears from tape, in the Read Stats. The Read Stats are numbered RIB0-5 and RIBP. When the character held there has been dealt with the stats are reset by StIRRS (para 5.5)

8.8.6 Programming Notes

These notes are to be considered as supplementary to the previous paragraphs and are not complete in themselves. They are provided to help in writing the extracode programmes necessary for controlling the Tape Control Unit.

6.1 Setting Orders in the V store

Orders are initiated by writing a 'one' to one and only one of the six order digits (line 1 digits 24-29) in the V store.

6.2 End of Operation Look At Me, ELMI. (Type 14 line 24 digit 31)

This Look at Me is set when the order has been carried out and all the information required by the extracode routine has been set in the V store (paras 4.2 and 5.11.1). No attempt is made to deal with the failures as they occur (with the one exception given in para 6.7.3c) once the order has been accepted. The digits giving information on failures are inspected as part of the End of Operation interrupt routine.

6.3 Putout End of Operation Look at Me IRELMI, (line 1 digit 30)

As IRELMI is used to clear the Tape Control V store (para 5.12) all the required information contained in the V store must have been extracted before IRELMI is sent to Tape Control. All other digits in line 1 must be zero when IRELMI is sent to Control.

A new order should not be sent to the Control Unit within 1.5/usec of sending IRELMI.

6.4 Rewind in Progress and the Disengaged Digits (line 0 digits 28-33)

When a rewind is initiated on a tape unit the unit disengages itself, setting the TU Disengaged digit. The tape unit remains disengaged until the rewind is completed. If the 'Reset' key has not been pressed during the rewind or if the order is not a Rewind and Disengage Order the tape unit then re-engages itself and the TU Disengaged digit falls to the zero level.

6.5 End of a Read Order.

When ELMI is set at the completion of a read order a test must be made on the Character Count (see para 5.6.2.3.)

6.5.1 Character Count not zero: The count gives the number of characters to be read from the buffer. These odd characters are held in the more significant end of the buffer.

6.5.2 Character Count zero: a zero count means that the buffer is empty. This is unlike a Write Order where zero in the Character Count means that the buffer is full.

6.6. Backspacing the tape

Although reading tape Backwards is not allowed the parity checks are performed correctly when a Backspace order is carried out.

6.7. Failures

The following failures may be detected by extracode:

6.7.1. Lateral and Longitudinal Parity Failures PILA, PILO.

Digits 25 & 26. Line 1 may be set, while reading from or writing to tape, due to detection of errors caused by imperfections in the magnetic tape.

6.7.2 Buffer Attention Overdue Digit 24 line 1 will be set if information is being destroyed due to the inability of the Buffer Attention interrupt routine to transfer information to or from the buffer in the required time, (para 5.6).

6.7.3 Mechanical Failure, FIM Digit 29 line 1 may be set as Follows:

(a) 5/us after an order is sent to the V store a test is made to ensure that the selected tape unit is responding to initial instructions from Tape Control (para 5.7.2). If this is not so the order is abandoned and ELMI and FIM are set. However Lateral and Longitudinal parity failures will not have occurred and PILA and PILO should not be set.

8.8.6 Continued..

This failure may simply be due to the selected tape unit being disengaged, which can be checked by inspecting the TU Disengaged digit.

(b) Sporadic Writing failure during a Write Order:

If the writing mechanism in the tape unit fails sporadically at some period while writing a block a character may not be written on tape. When this occurs no Write Echo pulse will be received in the Tape Control and FIM is set. However writing will not stop and the block will be completed before this failure will be detected.

It is very probable that either or both PILA and PILO will be set.

(c)Continuous writing failure during a Write Order:

If 3 or more consecutive characters fail to be written on tape then the Record Gate Logic will think that the end of the record has been found and will set ELMI even though the Write Order has not been completed by the extracode programme. FIM is set and so very probably are PILA and PILO.

(d) Total writing failure during a Write Order:

If the writing mechanism has failed before the first character is written to tape no characters are ever written to tape. In this case the Record Gate Logic never becomes operative and it is only entered by reading a character from tape. As the Record Gate Logic is responsible for setting ELMI when the tape system is working correctly a different method of setting ELMI is provided in this case. ELMI is set 3ms after Write Control has dropped the Write Check Character line. This provision is overidden when the tape system is working correctly.

(e) If the 'Reset' key on a tape unit is pressed while it is carrying out an order from the Control Unit, ELMI and FIM are set within about 150 m/usec of the TU Disengaged line rising to the 'on' level. This condition may be diagnosed by the fact the ELMI, FIM and TU Disengaged are all 'on'.

As parts of the Tape Control unit may continue functioning after ELMI is set this debris must be cleared out of the Control Unit before any further order, even on a different tape unit, may be obeyed. This may be done by sending two IRELMI signals to the Tape Control Unit with at least a 1/usec spacing between them. (i.e. two Put Out End of Operation L.A.M. signals).

8.9 The Instruction Counter and the Clock

The Instruction Counter

This consists of eleven digits with a one being added to the least significant of these digits every time an instruction is obeyed (except when the counter is stopped) on either Main or Extracode control. An interrupt occurs every 2048 instructions, (i.e. every time the most significant digit is changed from a zero to a one) to enable the drum learning program to bring up-to-date the record of which core store pages have been used since the last such interrupt.

It is possible to set these digits from the computer.

The information digits are cleared by pressing the Reset button on the Engineer's console and it is necessary for the Supervisor to write a one to the Start digit of the counter every time the machine is switched on. Any of the Supervisor routines which are obeyed on Extracode control preserve the existing value of the instruction counter and reset it after being obeyed, thus allowing a separate count to be assembled of instructions obeyed by the Supervisor.

The Clock

This is a Venner Transistorised Digital Clock situated in the console. It provides five outputs:-

1) a one-tenth of a second interrupt signal. No automatic count is made of these signals. This interrupt is to enable the Magnetic Tape supervisor to check the arrival of Block Address interrupts. It is also used by the log keeping program to add up the number of tenths of a second a program has been operating.

2) a one second interrupt. The routine associated with this interrupt

   a) checks whether any peripheral equipments or magnetic tape mechanisms have been engaged or disengaged since the last such interrupt.

   b) checks for fault conditions on the peripheral equipments e.g. a "tape out" digit being set for a Teletype punch.

   c) terminates magnetic tape wind or rewind operations when these are used as fast search operations.

   d) checks that the current programs have not exceeded their specified time limits.

   e) initiates routines run at fixed intervals i.e. engineers tests.

3) a one-hundredth of a second signal. This is used by the X-ray Diffractometer but it does not cause an automatic interrupt.

4) twenty information digits read from a V-store address. Of these digits six represent the hours (two for the ten digits and four for the units) seven represent the minutes and seven the seconds (three for the tens and four the units in each case).

8.9. Continued..

5) the time is displayed on the wall. This representation is in decimal form giving hours, minutes and seconds on a 24-hour clock basis. The output from the clock is not staticised and it is arranged that the clock is not switched off when the peripheral coordinator is off. The output goes through relays which prevent any signals going to the peripheral coordinator when this is switched off.

The One-second interrupt signal to the computer does not coincide with every tenth of the One-tenth of a second interrupt signals. In order that the information digits are not read as they are being changed a delay of 200 µsecs is built into the former signal. The time thus remains unchanged in the information digits for one second less 200 µsecs after every One second interrupt.

Separate interrupt and Put Out Look At Me signals are provided for the two interrupts with the One-second interrupts having the higher priority. Due to the 200 µsec delay the routine for this interrupt will however normally be obeyed after the corresponding One-tenth of a second interrupt routine; also the Clock Interrupt program is written so that if both interrupt digits are set on entering the program the One-tenth of a second routine is obeyed first.

It is possible to inhibit these interrupts (but not to stop the clock) either (a) by writing a one to the Stop digit or (b) by pressing the Reset button. Writing a one to the Start digit allows the interrupt signals through to themachine. It is thus necessary for the Supervisor to "Start" the clock before it may be used.

8.9. Continued..

V-Store Digits

Type 12 (*60043000)

(a) Instruction counter

line	digits		
0	46-36	RW10	Information. One is added in digit position 36 every time an instruction is obeyed except when (a) using interrupt control or (b) the counter is stopped.
	27	W1	Start
	26	W1	Put out "Look at Me"
	25	RW1	Stop

(b) Clock

1	45-44	R	hours, tens
	43-40	R	hours, units
	38-36	R	minutes, tens
	35-32	R	minutes, units
	30-28	R	seconds, tens
	27-24	R	seconds, units
	27	W1	Start
	26	W1	Put out 1 sec Look At Me
	25	W1	Stop
	24	W1	Put out 1/10 sec Look At Me.

Type 14 (*60043400)

line	digit		
0	24	R	Instruction Counter Look At Me
	25	R	Clock, One-tenth Second Look At Me
	26	R	Clock, One Second Look At Me

8.10.1 The On-Line X-ray Diffractometer. (OLDMAN)

1. Nature of the equipment

The equipment consists of X-ray detector(s), a crystal orienter (a 4-circle goniometer), an X-ray source and a control unit.

1.1 The X-ray Detector

The detector can be either a scintillation crystal or a proportional counter. In the Manchester University installation a scintillation crystal is used. This is directly coupled to a photomultiplier tube, the output of which is fed through a pulse-height analyser to the control unit which arranges for the detected pulses to be counted.

1.2 The 4-circle goniometer

The X-ray detector is mounted on an arm (the counter arm) which can rotate about a vertical axis. This axis is called the 2θ (two-theta) axis, and the horizontal plane described by rotation of the counter arm about this axis the 2θ-plane. The X-ray beam (see below) intersects the 2θ axis at right angles and is adjusted, mechanically, to lie within the 2θ plane. The crystal is placed at the intersection of the X-ray beam and the 2θ axis. The crystal is mounted, usually on a fine fibre, on a three-circle (i.e. a 3-axis,) device which permits the adjustment of the crystal to any orientation with respect to the incident X-ray beam. The three axes of this device intersect at a point, which is the crystal location, and permit rotation of the crystal about (i) a vertical axis, the ω (omega) axis, (ii) a horizontal axis lying in the 2θ-plane called the χ (chi) axis and (iii) a third axis, the ϕ (phi) axis of variable inclination.

The ω and 2θ axes are thus coincident; the chi circle is mounted on the ω axis and turns with the ω axis. The ϕ circle is mounted on the chi-circle so that the ϕ axis is vertical and coincident with the ω and 2θ axes when the chi-angle is at 0° and 180° and is contained in the 2θ-plane at the chi-angles of 90° and 270°. At other chi-angles the ϕ axis makes an angle whose value is chi with the ω axis.

There are thus four independent angular shaft settings required to position the goniometer and counter arm. The angular positions of each of these four circles will be sensed by Moiré fringes which permit setting accuracies (in the case of the Manchester University instrument) of 1/100 degree for the ω, χ and ϕ axes and 1/50 degree for the 2θ axis. The instrument at Manchester University is based on a design of the U.K.A.E.A. neutron diffractometer.

1.3 X-ray Source

This consists of a collimated beam of X-rays usually produced from a molybdenum or copper target and may be stabilised or unstabilised. In the latter case provision is made for monitoring the output of the X-ray tube.

1.4 The Control Unit

This consists of the circuits associated with (i) setting the circle positions, (ii) counting the signals obtained from the pulse-height analyser(s) of the diffracted X-ray beam (and the monitor if provided), (iii) providing two-way information paths between the Atlas peripheral co-ordinator and the diffractometer.

It consists essentially of four main registers, two of which are 20 bits and two 18 bits long. In additional there are four special registers referred to as "Clamp registers" each 6 bits long. These latter four registers form part of the four closed loop servos associated with each circle of the 4-circle goniometer.

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8.10.1 Continued

Each of these eight registers can obtain access to a Half-Adder/Subtractor for the purpose of adding or subtracting one from the specified register.

The peripheral co-ordinator is able to write to, or read from, any of the eight registers.

1.5 The V-store Digits

Type 9

Line 5, (*60042250)

	Write		Read
Digit		Digit	
24-43	Information	24-43	Information
44	Load Information (LIv)	44	Reflected Count Overflow
45	Start Count (SCv)	45	Check read
46	Set the Position (SPv)		

Line 9, (*60042310)

Digit			
24	Disengage	24	Disengaged
25	2θ (Two-theta) (2θv)	25	2θ
26	W (Omega) (Wv)	26	W
27	ø (PHI) (øv)	27	ø
28	X (CHI) (Xv)	28	X
29	Z-line (Zv)	29	Clamp out of range
30	V-Reset	30	Limit switch failure
31	Clamp registers* (CRv)	31	References reached
32	Read selected register (RIv)	32	Test A
33	Put out position set L.A.M.	33	Test B
34	Put out count complete L.A.M.	34	Test C
35	Put out contingencies L.A.M.	35	Test D
36	Open shutter	36	Test E
37	Close shutter		
38	Drive W - circle (CWDRv)		
39	Drive 2θ - circle (2θDRv)		
40	Drive to references (DRv)		

Line 13 (*60042350)

Digit			
24	Test and isolate motors and nucleonics (TIMN)		
25	Reset test and isolate motors and nucleonics (RESET-TIMN)		
26	Test-count-start	*	(TCS)
27	Test-count-stop	*	(TCst)
28	Test set-add	*	(TSA)
29	Test set-subtract	*	(TSS)
30	Test add ± 1	*	
31	Test fringes		(TFv)

Type 14

Line 6 (*60043460)

25	Position Set	Look At Me
27	Count Complete	Look At Me
29	Contingencies	Look At Me

8.10.1 Continued

1.6 The Z-line

The Z-line consists of ten staticisors which are accessible by writing to and reading from digits 24-43 of line 5 of type 9 of the Peripheral V-store. This is a special line associated with controlling the X-ray beam, i.e. it enables the beam to be centred using four controls and it provides for the insertion or removal of filters, attenuators, etc.

Writing a one to digit 29/9 causes the subsequent information sent to line 5 to be transferred to the Z-line, the transfer taking place when a one is written to digit 44/5.

The digits in the Z-line are:

Write		Read	
Digit		Digit	
24	Set window 1	24	Window 1 in
25	Reset window 1	25	Window 2 in
26	Set window 2	26	Window 3 in
27	Reset window 2	27	Window 4 in
28	Set window 3	28	Balanced filter 1 in
29	Reset window 3	29	Balanced filter 2 in
30	Set window 4	30	Attenuator 1 in
31	Reset window 4	31	Attenuator 2 in
32	Set balanced filter 1	32	Counting clock
33	Reset balanced filter 1	33	Motor speed 1
34	Set balanced filter 2		
35	Reset balanced filter 2		
36	Set attenuator 1		
37	Reset attenuator 1		
38	Set attenuator 2		
39	Reset attenuator 2		
40	Count clock		
41	Count X-Rays		
42	Set motor speed 1		
43	Set motor speed 2		

8.10.2 Basic Operations.

There are seven basic operations performed by the device.

These are:-

(1) Clamping
(2) Loading information
(3) Reading information
(4) Setting a position
(5) Counting
(6) Driving to and between circle reference markers
(7) Testing

All the V-addresses associated with this device are Type 9. Consequently only digit and line numbers are referred to (e.g. 33/9 means digit 33 of line 9).

2.1. Clamping

There are four clamp registers, one associated with each of the ω, 2θ, ϕ and χ registers. Each register can be up to 6 bits long. Of these the most and the next-most significant digits are a guard and sign bit respectively. The remaining bits are used to clamp to circles to their set positions within 15 quarter fringes (i.e. $15/100^{\circ}$). Thus, any circle can be $+15/100^{\circ}$ to $-16/100^{\circ}$ away from its set position without the device losing count of this position. The clamp registers are used in conjunction with the circle servos to attempt to keep the clamp registers reading 0, this indicating zero clamping error.

Clamping is always operative except when
(1) the circles are being set to new positions,
(2) the circles are being driven to or between references and
(3) an X-ray intensity measurement is being made which involves the movement of the ω and/or 2θ circles, during the counting.

After setting a position, driving to a reference marker or taking a count, clamping again becomes operative.

If the sign and guard bits of the clamp register take different values, then the clamp becomes 'out of range', i.e. the system will lose the positional information of the circle or circles concerned. This is indicated to the Atlas by giving a 'Contingencies' Interrupt and setting 29/9, together with one of 25/9→28/9 to 'one'. The Contingencies Interrupt routine identifies the cause of the interrupt by inspecting 29/9, 30/9 and 31/9, and the circle concerned by inspecting 25/9→28/9. Writing to 35/9 puts out the 'Contingencies' L.A.M. and resets 29/9 and 25/9→28/9 to zero. It also resets 30/9 and 31/9 and hence these must be checked for a further interrupt before writing to the Put Out L.A.M. digit.

2.2. Loading Information.

Information can be written from Atlas into any one of the four registers ω, 2θ, ϕ, and χ and also into the 'Z-line'. This is achieved by setting 44/5 which causes the information present on 24/5→43/5 to be written into the register specified by 25/9→29/9. 30/9 must also be set along with one of 25/9→29/9; this digit resetting 25/9→29/9 before they are set.

8.10.2 Continued..

The information is loaded through the Half Adder/Subtractor buffer, at the input gate of which it exists for 4 μs. The 'Load information' digit 44/5 is regarded as an internal OLDMAN interrupt, and is thus dealt with as soon as the Rhythm Unit is free. This free condition is guaranteed to occur not more than 450 μs after the load information digit is set; the actual loading of information will take about 200 μs, thus if the information is available for at least 1 μs it will be loaded correctly. The normal peripheral co-ordinator operation will ensure that it is available for 4 μs.

2.3. Reading Information Into Atlas.

Information can be read into Atlas from any of the eight registers.

Two V-orders are needed to read information into Atlas.

(1) Write to 32/9 specifying Read, together with one of 25/9→29/9 selecting the register to be read (30/9 must be set for reasons given in 2.2.)

This order must be immediately followed by the order

(2) Read Line 5. The information will be present on Digits 24-43 together with a check read Digit (45) which is always set to one on reading.

The rhythm of the read information sequence is that the setting of 32/9 (read selected register) is regarded as an internal OLDMAN interrupt which will be dealt with not later than 450 μs after setting 32/9. The Rhythm Unit then makes available at the Peripheral Co-ordinator, for a period of about 10 μs, the information contained in the register selected by 25/9→29/9.

2.4. Setting A Position.

The settings of the four circles ω, 2θ, ϕ and χ are known by the Atlas. (Each circle has at least one well-defined reference point from which the Atlas can compute positional information).

Setting a position involves loading the four main registers with four differences, these being the differences between the present settings and the desired settings. Positional differences are 18-bit binary numbers where the most significant digit specifies the sign of the difference and the remainder the magnitude in steps of $\frac{10}{100}$ for the ω, ϕ, and χ circles, and of $\frac{10}{50}$ for the 2θ circle.

The differences are loaded in the manner specified in Section 2.2.

Setting 46/5 during the loading of the last difference information causes the Rhythm Unit to move all the circles by the indicated differences to set the new positions.

Setting proceeds at full speed when the difference exceeds $|2^5|$ and at a reduced speed when $< |2^5|$. This system is used to avoid unnecessary overshoots when the position is being set.

When a circle has been set, it is returned to the clamping state.

When all the circles have been set, a 'Position Set' L.A.M. is given to the Atlas. This is put out by writing to 33/9.

8.10.2 Continued..

2.5. Counting.

Several methods of counting the diffracted quanta from a crystal can be employed.

In all cases the counting can be for a defined time (Count Clock) or for a defined Monitor Count (Count X-Rays). The method used is selected by digits 40 or 41 of the Z-line.

The count may be made with

(1) All circles stationary

(2) ω circles moving at one of 2 speeds

(3) 2θ " " " " " 2 "

(4) ω and 2θ circles moving at one of 2 speeds, these being in the ratio ω : 2θ of 1:2.

The actual counting method to be used is selected by setting appropriate V-digits before the commencement of the count. In all cases a positive number must be loaded into the χ register to specify either counting time or monitor count. This number is a 20-bit positive number.

If Counting Clock, then this number will be reduced by one every $\frac{1}{100}$ sec. If Counting X-Rays it will be reduced by one every time a pulse is received from the Monitor circuit. In both cases counting will continue for as long as it takes for the contents of the χ register to be reduced to zero. (This count number must obviously be loaded after the circles have been set, and is done as indicated in Section 2.2.).

If the count involves movement of the ω and/or 2θ circles, then a record of the angles through which these circles are moved during the counting is kept in the ω and 2θ registers. This information can be read by the Atlas in order for it to up-date its circles-position log.

Counting is initiated by setting 45/5. (Normally in the same V-order 24/5 $\rightarrow$ 43/5 and 44/5 will be set to load the count number).

Prior to initiating the count digit 40 or 41 of the Z-line must have been set to count clock or X-Rays, also if the count involves movement of the ω and/or 2θ circles digit 42 or 43 of the Z-line must have been set to determine circle speeds.

The Rhythm Unit first inspects 38/9 and 39/9 to determine whether or not to move the ω and/or 2θ circles. Digit 36/9 must have been set to open the shutter. The shutter can be opened at any time but counting will not commence until the shutter actually has opened; closure of the shutter is done automatically when the count ends or by writing to 37/9.

Counting stops when the contents of the χ register reach zero. If the ω and/or 2θ circles have been moved during this time then they are stopped and clamped in the new position. 38/9 Drive ω -circle and 39/9 Drive 2θ circle are reset to zero and the shutter closed.

A 'Count Complete' L.A.M. is given. This is put out by writing to 34/9.

If during the counting an overflow occurs in the ϕ register (i.e. 21st bit) then 44/5 is set. This may be read when reading the count information to determine the validity of the count. This digit is reset to zero at the commencement of a count.

8.10.2 Continued..

Setting 26/13 starts the system counting in any four registers specified by 25/9→28/9 and 31/9 i.e. all 4 main registers or all four clamp registers. The counting pulses are generated from a 2 μs oscillator, thus +1 gets added to or subtracted from (according to 28/13 and 29/13) the nominated registers every 2 μs. This operation is used to test the time-sharing control of the system. (A manual adjustment of the frequency of the oscillator will be provided to check the time-sharing limits of the system). This counting continues until 27/13 is set. The total counts are left in the registers for reading into Atlas.

At any time, setting 25/13 returns the system to the operational state, the circles clamping in whatever position they happen to be.

31/13, the Test Fringes digit, is used in conjunction with 40/9, the drive to references digit, to test the operation of the fringe system. The system should be driven to the reference points and when it is at the reference points, if 31/13 is set, all circles will drive to a second reference point counting fringes as they go. The counts obtained between references should be constant. When the second references are reached the circles are stopped, but the clamps may go out of range as no provision is included for approaching the second references at slow speed. Thus absolute positional information may be lost. A Contingencies L.A.M. is given which is identified as 'Second References Reached' by 31/9 being read as one. A new absolute position is found by driving to references by setting 40/9.

2.8. Extras.

Limit switches are provided on all the 4-circles of the goniometer. Limit switches should not be activated in the normal course of operation of the instrument. When a circle hits a limit switch then the supplies to the motors of all circles are cut off and a 'Contingencies L.A.M.' is given. Investigation of 29/9→31/9 will reveal that there is a limit switch failure. The equipment should be disengaged by writing a one to 24/9 (which inhibits all L.A.M.'s) and the engineer informed. A manual engage/disengage button will be provided following standard peripheral equipment procedure, the state being indicated to Atlas by 24/9 which is set to one when the equipment is engaged. This digit reads one for engaged rather than disengaged as on the other peripherals because cable drivers and receivers are used instead of the standard Atlas connections.

2.6. Referencing.

Since all the position setting is done by driving the circles through incremental differences, at least one well defined point per circle must be provided to permit the conversion of relative positions to absolute positions. This is achieved by providing at least one reference point per circle. The accuracy of the reference points will be at least as good as that of the setting mechanism (i.e. to better than 1/100 degree).

The reference points will be placed at one end of the limit of travel of each circle, a small distance away from limit switches; also, a small distance away from the reference point on the operational side will be a reference marker. This marker is used to indicate whether or not a circle is between the reference marker and the reference point. Setting 40/9 to a one causes all circles to be driven to their reference points.

If when referencing commences, the circle is outside the reference marker then it will drive at high speed until it crosses the reference marker when it will be switched to low speed. If when referencing commences it is inside the reference marker then it drives only at low speed. This is done to prevent the overshoot, which will be put into the clamp-register, from putting the clamp out of range which in turn would cause the circle to clamp on a point other than the reference point itself.

When all the circles have reached the reference point then a 'Contingencies L.A.M.' is given and 31/9 is set to 'one'. Atlas identifies the 'Contingencies L.A.M.' as being 'References Reached' by reading 31/9 as a 'one'.

The incremental differences through which the circles have been moved to reach their reference points are stored in the four registers ω, 2θ, ϕ and χ and are consequently available to be Read (Section 2.3) by the Atlas in order for it to check its position log.

2.7. Testing.

Several V-digits are provided to permit testing (by programme). The testing is mainly confined to the Central Unit of the device, but does include a facility to permit the testing of the Moire Fringe Systems.

V-digits marked thus (*) are only operative when 24/13 is set to one. This digit when set isolates the motors (i.e. the circles are free), inhibits internal OLDMAN interrupts from the circle fringes and isolates the Nucleonics circuitry. In this state special signals from a Test Programme can be fed into the Rhythm Unit through the Test V-digits to facilitate the testing of the Central Unit.

Information can be written to and read from any of the four main registers in the manner already presented in Sections 2.2 and 2.3 In addition, in the Test state, setting 31/9 together with one of the 25/9→28/9 permits writing to and reading from the clamp registers.

In the Test state all L.A.M.'s are inhibited, and a number which puts a clamp register out of range can be written to check that the appropriate digits (25/9→29/9) are set to one thus indicating to the Atlas the out of range state.

All information which is being loaded sets Tests A,B,C and D thus if suitable numbers are loaded then the Test A,B,C and D digits (32/9→35/9) will be set, enabling the Tests to be checked.

Testing of the Half Adder/Subtractor is achieved by use of 30/13. Each time this digit is set, +1 is added to or subtracted from the contents of the 2θ register according to whether 28/13 or 29/13 is set to one. The operation takes about 450 mus and thus there is no limitation on the frequency of V-orders to add +1.

8,11 GRAPHICAL OUTPUT

This equipment provides a means of displaying, in graphical form, the output from a computer. Information in the form of illuminated spots. is sent from the computer to a Cathode Ray Tube, which has a display area of 8 cm.sq. The resultant display is photographed on 35 m.m. film by a Shackman camera. The display can have a maximum array of 1024 x 1024 illuminated spots with 1024 spots on the x-axis, which is horizontal, and 1024 spots on the y-axis, which is vertical. Each illuminated point has a diameter of 0.4 m.m. with a "bright up" time of 1 μsec. The camera has to be wound-up manually but signals from the computer control the opening and closing of the shutter and winding on of the film.

Each reel of film contains 200 frames. There is no mechanical counter showing the number of frames not yet exposed.

Controls and Indicators.

a) Power ON/OFF switch and Mains on indicator

This is an ordinary "tumbler" switch, similar to the power ON/OFF switch on the teletypes. The indicator is lit RED when the mains power is on.

b) ENGAGE/DISENGAGE switches and indicators

These are two single action switches and indicators. The equipment can only be engaged by push-button but may be disengaged either by push-button or by a signal from the computer. When the equipment is engaged the Engage button is lit Green and the Disengage button is lit White; when the equipment is disengaged the Engage button is lit White and the Disengage button is lit Red.

c) CAMERA FAULT indicator

This indicator is normally unlit but, when a Camera Fault exists it is lit Yellow. The fault condition exists when

(i) the camera is not fitted
(ii) the camera has no film
(iii) the film is jammed in the camera

d) SHUTTER OPEN indicator

This indicator is in darkness when the camera shutter is closed and it is lit Yellow when the shutter is open.

The V-store digits:

Peripheral V-store Type 3. (*60040600)

line	digit		
0	27	RW1	Read: Camera Fault Write: Start
	26	RW1	Read: Brilliance Write: Put Out Look At Me
(Command Register)	25	RW1	Stopped/Stop
	24	RW1	Disengaged/Disengage

8.11 Continued

line	digit		
8	47-38	W1	x - co-ordinate (in binary, digit 38 least significant)
(Transfer Register)	35-26	W1	y - co-ordinate (in binary, digit 26 least significant)
	25	W1	Display
	24	W1	Dim

Look At Me Type 15 (*60043620)

line	digit		
2	24	R	Look At Me

Signals to and from the computer

To engage the Graphical Output it is necessary to press the Engage button; it is not possible for the equipment to be engaged directly by the computer. Pressing the Engage button sends a pulse which resets the Disengaged digit in the V-store (digit 24) to zero.

On writing a one to the Start digit (digit 27) the following events occur:

(i) the Stop digit is reset to zero.
(ii) the film is wound on one frame.
(iii) the camera shutter is opened (if closed)
(iv) the Brilliance digit is reset to zero.
(v) after a delay of 1/8th of a second a Look At Me signal is sent to the computer.

On writing a one to the Stop digit (digit 25)

(i) the Stop digit is set to read one.
(ii) the camera shutter is closed.

A point is "plotted" on the C.R.T. by sending its (x, y) co-ordinates and simultaneously writing a one to the Display digit. The effect is to "Bright-up" the specified spot for 1 μsec. Two intensities of illumination are possible, namely "Bright" & "Dim". "Bright" illumination is automatically selected unless a one is written to digit 24 in the same instruction that the x, y co-ordinates and the Display digit are transferred. It is necessary for the program to plot any axes that are required.

Points may be illuminated on the C.R.T. at any time but they can only be photographed when the camera shutter is open.

The Graphical Output can deal with information as fast as it can be transferred from the computer to the V-store (maximum rate, one reference every 5 μsecs.) and there is no maximum time interval between sending commands or information. Consequently the computer plots points on Extracode control so that other interrupts may be dealt with as they occur.

No provision is made for indicating to the computer whether the camera shutter is opened or closed or the film has moved on after a start command (except when the film is jammed and the Camera Fault digit is set). A Look At Me signal is however given 1/8 sec. after a Start signal is given and it is anticipated that the specified mechanical action will have been completed in this time.

8.11 Continued

After all the points for one frame have been plotted and before the film is wound on, the computer reads the "Brilliance" digit (digit 26). This is used in conjunction with circuits inside the C.R.T. to determine whether a certain number of Bright-up pulses has beeen detected on the face of the tube. If an insufficient number of pulses has been detected the Brilliance digit is not set. This latter digit is automatically reset on writing a one to the Start digit.

Digit 27 is read as one if a Camera Fault condition exists. This digit is automatically reset when the fault is cleared.

10.1 The Engineer's Console

A control panel for engineering use only is provided which contains the following controls and indicators:-

1) Display

A set of 24 lights which are addressed as B120 for output purposes. If an attempt is made to read from B120 a zero operand is obtained.

2) Parity Circuit On/Off Buttons

There are six parity circuits in the computer but these do not have a one to one correspondence with the six parity interrupts. For each circuit there is a double action push button for switching the circuit on and off. There is a light behind each button which is lit when the circuit is switched off. The six buttons are for

a) Parity A

This circuit checks all instructions with even addresses read from the core store, all operands read from the core store, and the information read from the core store being written to either the magnetic tape or the drums.

b) Parity B

This circuit checks all instructions with odd addresses read from the core store and all information written to the core store from the drum and tape co-ordinators. It also generates a parity for information written by the machine to the core store.

c) Parity C

This checks instructions and operands read from the subsidiary store.

d) Parity D

This circuit generates parity for information written to the subsidiary store.

e) Parity E

This circuit checks instructions and operands read from the fixed store.

f) Parity F

This circuit checks the output of the magnetic tape buffer on writing to tape. It also generates parity for information read from magnetic tape.

3) Parity Indicators

There are thirteen lights which indicate whether incorrect parity has been detected on reading

a) an instruction with even address from the core store
b) an instruction with odd address from the core store
c) an operand with even address from the core store
d) an operand with odd address from the core store
e) information from the core store for transfer to a drum
f) information from a drum for transfer to the core store
g) information from the core store for transfer to the tape co-ordinator
h) information from the tape buffer for transfer to magnetic tape
i) information from the tape buffer for transfer to the core store
j) an instruction from the subsidiary store.

k) an operand from the subsidiary store
l) an instruction from the fixed store
m) an operand from the fixed store.

Where an instruction or 48-bit operand is involved the parity digit is checked for each 24-bit half word. If a 24-bit operand is called for, the parities of that half word and also the other half word in the 48-bit word are checked.

4) Parity Lamp Reset

The parity indicator lights listed above remain lit after the appropriate interrupt flip-flops have been reset by programme. A push-button with a light behind it which is always lit when the machine is switched on is provided which puts out any indicators which are lit when it is pressed.

5) Manual Order Handkeys

Fortyeight keys are provided to enable a manual order to be carried out. They are arranged in two sets of twentyfour with the upper row comprising ten keys for the function, seven keys for Ba and seven for Bm. The lower twentyfour keys are for the operand or the address of the operand.

6) Operand Buttons

Eight push buttons are provided which can be read as digits 31-24 of line 7 of the Central Computer V-store. These are double action buttons with lights behind them and the light is on when the digit is read as a one.

7) Engineers Interrupt Button

This is a single action push button with a light behind it which is always lit when the machine is switched on. On pressing the Engineers Interrupt button three actions take place

a) a digit in the Central Computer V-store (digit 27, line 5) is set to one. and the Engineers Reader and Punch switched on.
b) the address of the first instruction in this Engineer's Tests (2560 in the Fixed Store, total 4005,0000) is sent to Interrupt Central.
c) control is switched to Interrupt Control. No record is kept of the state of the I/ME digit and hence it is not normally possible to resume any programmes that were being carried out when the button was pressed.

Exit from the Interrupt is by programme depending on a pre-determined number being set on the Engineer Handkeys. The Interrupt is cancelled by re-setting the V-store digit by programme, which automatically switches the Engineers Reader and Punch off, and transferring control as required.

8) Stop Half Adder Button

Under normal circumstances, whenever an instruction is obeyed, one is added to the current control number and the next instruction is extracted either from the appropriate store or from the Present Instruction Odd register. The Stop Half Adder button is a means of preventing the one being added and the next instruction being extracted. A light behind this button is lit when in the Stop state.

9) Auto Rate/Manual Rate

This is a double action push button with lights behind the upper and lower halves of it. The light behind the upper half is lit when the computer is obeying instructions at the normal speed (Auto Rate). The light behind the lower half is lit when it is required to obey instructions not at full speed (Manual Rate).

10) 100 K.C.S./Stop

When on Manual Rate instructions may either be obeyed singly (i.e., by giving a single prepulse when on Stop) or so that one instruction is obeyed before the next one is started (100 K/Cs). This again is a double action button with either the top or bottom half lit.

11) Single

When the previous two buttons indicate Manual Rate and Stop respectively, a prepulse is given and an order obeyed each time the Single button is pressed. The light behind this button is on all the time when the machine is switched on.

12) Auto Order/Manual Order

This is a double action push button with lights behind the upper and lower halves. A light behind the upper half (Auto Order) indicates that orders are being obeyed from the store. A light behind the lower half (Manual Order) indicates that the order currently on the handkeys is being obeyed. In either case the speed at which orders are being obeyed is governed by the Auto Rate/Manual Rate button.

13) Reset

Pressing this button resets various rhythm controlling flip-flops throughout the machine. It also resets the contents of B120 (Display) to zero. It is normally used only when the machine has just been switched on. This button has a light behind it which is lit when the machine is switched on.

14) Start

When the machine is switched on the various flip-flops are set in an arbitrary manner and also one or more spurious prepulses might be in the machine. It is therefore necessary to switch to Stop (Auto/Manual to Manual, and Stop) to get rid of the spurious prepulses, to press the Reset button, to press the Engineer's Interrupt button, to switch back to Auto and to press the Start button. Conditional upon the number set up on the Engineer's Handkeys various initial test programmes are obeyed and the necessary flip-flops set to a standard state (e.g. the Look at Me's are reset).

The button must be pressed to give a prepulse on switching back from the Stop state to Automatic Rate. There is a light behind this button which is lit whenever the machine is switched on.

15) Prepulse Volume Control

This controls the volume of sound from the hooter of a steady note generated by an oscillator. The oscillator is rendered operative when prepulses are being obeyed continuously (at more than 10 Kc/s).

16) V/Address Volume Control

This controls the volume of the output from the hooter addressed as digit 27 of line 7 of the Central Computer V-store.

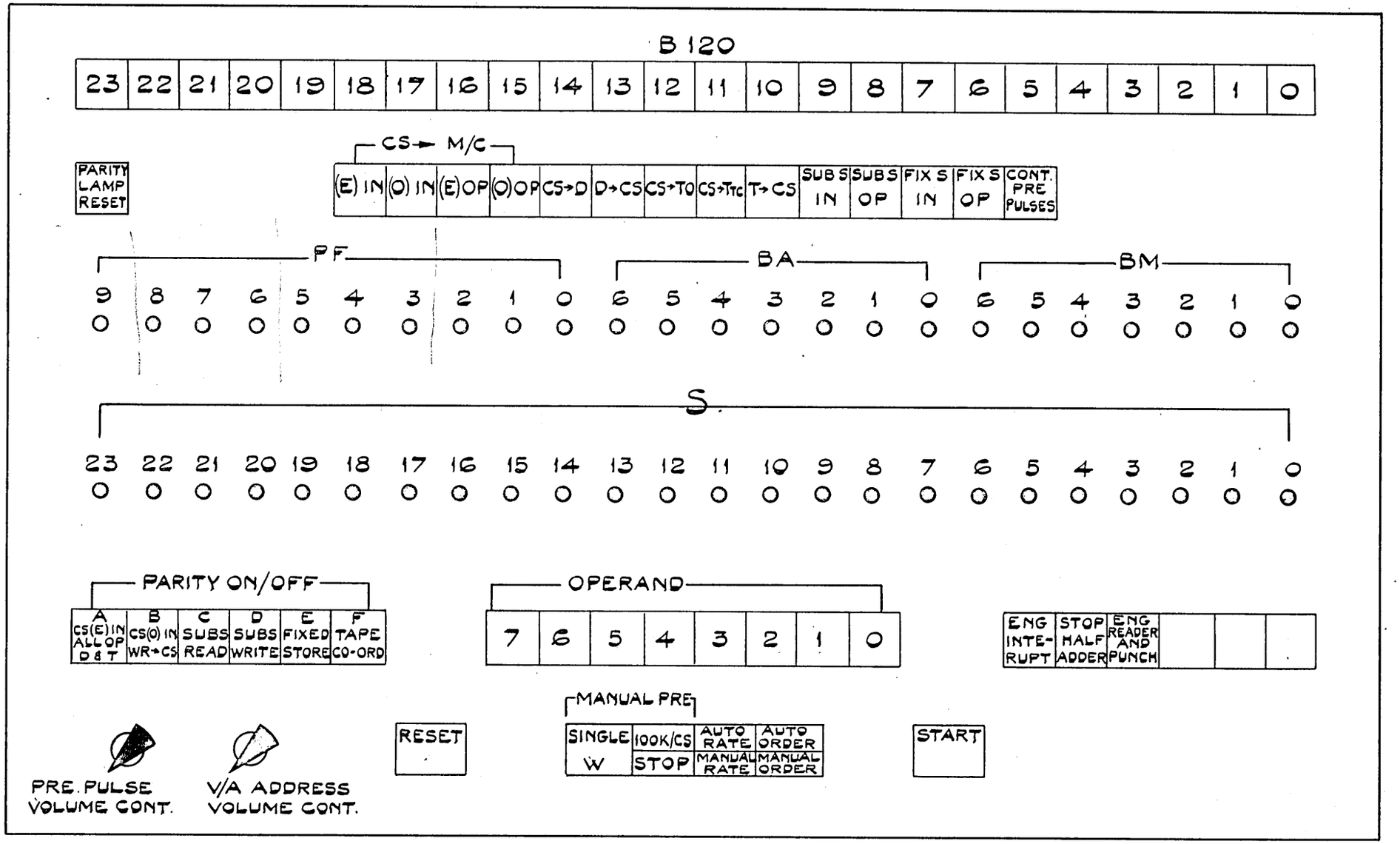
17) Continuous Prepulses Indicator

This indicator is lit under normal conditions when prepulses are being continuously supplied.

18) Reader and Punch Indication

This light is on when the Engineer's Reader and Punch digit in the Central Computer V-store is set to a one i.e. when the reader and punch are switched on.

ATLAS ENGINEERS CONSOLE.



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10.2 The Engineer's Paper Tape Reader

This is provided to give a simple means of input during the Engineers test programs. It is automatically switched to this mode when the Engineer's Interrupt button is pressed and it remains so until the "Engineer's Reader" digit in the Central Computer V-store is reset (line 3, digit 27). It may also be switched to this mode by writing a one to this digit. The equipment used is T.R.5 number 0. The Engage button on the reader need not be pressed before the equipment can be used.

The reason for always using this reader for engineering purposes is that there is an automatic hold up of instructions which read from or write to the peripheral V-store during Engineers Interrupt if the engineers reader is started and busy. This leads to a simpler method of operation for the computer because the normal interrupt programs for the reader are not entered.

During normal operation of the computer (i.e. when not on Engineers Interrupt) this reader is operated in the standard manner.

The Stop command is given after reading each character but providing another Start signal is given before the next location hole is detected the reader operates at maximum speed.

When on Engineers Mode the interrupt action is different from that on normal operation of the computer. If an interrupt occurs when on Main or Extracode control the fixed store address *40060000 is forced into B125 (instead of *40040000). The fixed store contains the following orders in this and the subsequent address.

```
*4006        124,    127,     0,     0     set pair flip-flop to not pair
             121,    125,   118,     0     jump to address specified in B118
```

This facility is used in various test programs.

Section 11 DETAILS OF THE ATLAS COMPUTER INSTALLATIONS

11.1 The Manchester University Atlas (Muse)

Muse is an Atlas I computer with

16,384 words of core store in two pairs of stacks.
8,192 words of fixed store.
1,024 words of subsidiary store.
4 M.D.5 drums (24,576 words each).
8 Ampex Tape Mechanisms (8 channels)
1 I.C.T. type 593 Card Reader (600 cards per minute).
1 I.C.T. type 582 Card Punch (100 cards per minute).
1 Anelex Line Printer series 4-1000 (maximum 1000 lines per minute).
4 TR5 paper tape readers (300 characters per second).
4 Teletype paper tape punches (110 characters per second).
1 TR7 paper tape reader (1000 characters per second).
1 Creed 3000 paper tape punch (300 characters per second).
2 Creed 75 teleprinters (10 characters per second).
1 Venner Clock.
1 Graphical Output.
2 N.E.P. tape mechanisms (1000 characters per second)
1 X-ray Diffractometer
1 Engineer's console.

11.2 The London University Atlas

This is an Atlas I computer with

32,768 words of core store in four pairs of stacks.
8,192 words of fixed store.
1,024 words of subsidiary store.
4 M.D.5 drums (24,576 words each)
8 Ampex T.M.2 Magretic Tape Mechanisms (8 channels with one 2 × 8 switching unit).
2 I.C.T. Type 593 Card Readers (600 cards per minute).
1 I.C.T. Type 582 Card Punch (100 cards per minute).
2 Anelex Line Printers series 4-1000 (maximum 1000 lines per minute).
4 T.R.5 paper tape readers (300 characters per second).
4 Teletype paper tape punches (110 characters per second).
3 Creed 75 teleprinters (10 characters per second).
1 Venner Clock.
1 Engineer's Console.

11.3 The N.I.R.N.S. Atlas

This is an Atlas I computer with

49,152 words of core store in 6 pairs of stacks.
8,192 words of fixed store.
1,024 words of subsidiary store.
16 Ampex Type T.M.2 Magnetic Tape mechanisms (8 channels with four 2 × 8 switching units).
4 M.D.5 drums (24,576 words each).
2 I.C.T. type 593 Card Readers (600 cards per minute).
1 I.C.T. type 582 Card Punch (100 cards per minute).
2 Anelex Line Printers series 4-1000 (maximum 1000 lines per minute).
2 I.B.M. type 729 Mark 4 Magnetic Tape Units (one channel).
3 T.R.5 paper tape readers (300 characters per second).
3 Teletype paper tape punches (110 characters per second).
1 Venner Clock.
1 Engineer's Console.

Section 12 Interrupts

12.1 The Interrupt Flip-Flops

The fixed store contains various routines which, together with certain built-in machine facilities, control the organisation of, and transfers of information between the core store and, the peripheral equipments, the magnetic drums and the magnetic tapes. These routines also determine the action to be taken if a parity failure is detected, or if a programme sets the exponent overflow register, divides by a non-standard or zero number in certain of the division orders, attempts to obey an unassigned function or refers to one of the private stores illegally.

A special control, Interrupt Control (B125), is provided and whenever action is required for one of the above reasons control is automatically switched from either Main or Extracode Control to Interrupt Control. Associated with each cause of interrupt there is a flip-flop in the V-store which is set whenever an interrupt is required. In the case of the peripheral equipments these are called the "look at me" flip-flops. These flip flops are grouped together, with not more than eight per group, and are connected via various OR gates to one of eight digits in line 2 of the Central Computer V-store. Using the B-log facility (B123, see Section 12.2) it is thus possible to identify the cause of Interrupt in at most five instructions.

An Interrupt may occur at an arbitrary time with respect to any interrupt from another source and consequently a system of priorities is needed in case two or more interrupts occur simultaneously. Highest priority is given to parity failures and second highest priority to the peripheral equipments. Each peripheral equipment has a "critical time" during which certain action must be taken immediately after its "look at me" flip-flop is set. For example for the Hammer Printer information must be sent to the appropriate digits to indicate if the relevant character has to be printed within 1.3 m.s. of the interrupt signal or that character will be missed. The priorities for the peripherals are therefore based on these critical times i.e. an interrupt for an equipment with a short critical time is dealt with before a simultaneous interrupt for an equipment with a longer critical time.

The following table gives a list of all the possible interrupts arranged in order of priority. Where more than one equipment of a type is attached the one with the higher number has the higher priority. The table gives the addresses of the digits which are set for each interrupt in the Central Computer V-store (Vc), the Magnetic Tape V-store (Vm), the Drum V-store (Vd) or the Peripheral Equipment V-store, type 14 (Vp). For the peripheral equipments the critical time is also given where appropriate and for possible machine or programme faults the information to be printed out and the action to be taken are given.

Cause of Interrupt	V-store digits set	Critical Time or Information to be printed out.
Parity 1 (Core Store)	digit 31, line 0, Vc digit 31, line 2, Vc	p1 Also Page, Line, and Pattern Failing
Parity 2 (Drum Transfer)	digit 30, line 0, Vc digit 31, line 2, Vc	p2 r or w if r, Cabinet, Drum and Band if w, Page, Line and Pattern
Parity 3 (Magnetic Tape Transfer)	digit 29, line 0, Vc digit 31, line 2, Vc	p3 r or w if r, Channel if w, Page, Line and Pattern
Parity 4 (Subsidiary Store)	digit 28, line 0, Vc digit 31, line 2, Vc	p4 Line and Pattern
Parity 5 (Fixed Store)	digit 27, line 0, Vc digit 31, line 2, Vc	p5 Line and Pattern

Cause of Interrupt	V-store digits set	Critical Time or Information to be printed out.
Parity 6 (Magnetic Tape Buffer, Channels 7-0)	digit 26, line 0, Vc, (digit 34, lines 15-8, Vm) digit 31, line 2, Vc	p6 Channel
Non-equivalence when on Interrupt Control	digit 25, line 0, Vc digit 31, line 2, Vc	nei
I.B.M. Magnetic Tape End of Operation	digit 31, line 24, Vp digit 30, line 2, Vc	
I.B.M. Magnetic Tape Buffer Attention	digit 30, line 24, Vp digit 30, line 2, Vc	256μsecs
Card Readers 3-0 Column Ready,	digits 27-24, line 24, Vp digit 30, line 2, Vc	660/us
Magnetic Tape Block Address, Channels 7-0	digits 31-24, line 18, Vm digit 29, line 2, Vc	1 m.s.
Card Readers 3-0, End of Card	digits 27-24, line 23, Vp digit 31, line 31, Vp digit 28, line 2, Vc	2.5 m.s.
Xeronic Printers 1-0	digits 25-24, line 22, Vp digit 30, line 31, Vp digit 28, line 2, Vc	
T.R.7's 3-0	digits 27-24, line 20, Vp digit 28, line 31, Vp digit 28, line 2, Vc	1 m.s.
T.R.7 Checks 3-0	digits 27-24, line 19, Vp digit 27, line 31, Vp digit 28, line 2, Vc	1 m.s.
Graphical Outputs 1-0	digits 25-24, line 18, Vp digit 26, line 31, Vp digit 28, line 2, Vc	
Hammer Printers 1-0 Character Interrupt	digits 25-24, line 17, Vp digit 25, line 31, Vp digit 28, line 2, Vc	1.3 m.s.
Hammer Printers 1-0 Line Count Interrupt	digits 25-24, line 16, Vp digit 24, line 31, Vp digit 28, line 2, Vc	5.7 m.s.
I.B.M. Magnetic Tape Mechanical Failure	digit 25, line 15, Vp digit 31, line 30, Vp digit 27 line 2, Vc	—
Fast Paper Tape Punches 3-0	digits 27-24, line 14, Vp digit 30, line 30, Vp digit 27, line 2, Vc	4 m.s.
T.R.5 Paper Tape Readers 11-8	digits 27-24, line 12, Vp digit 28, line 30, Vp digit 27, line 2, Vc	3.3 m.s.

Cause of Interrupt	V-store digits set	Critical Time or Information to be printed out.
T.R.5 Paper Tape Readers 7-0	digits 31-24, line 11, Vp digit 27, line 30, Vp digit 27, line 2, Vc	3.3 m.s.
Teletype Punches 11-8	digits 27-24, line 9, Vp digit 25, line 30, Vp digit 27, line 2, Vc	9.1 m.s.
Teletype Punches 7-0	digits 31-24, line 8, Vp digit 24, line 30, Vp digit 27, line 2, Vc	9.1 m.s.
Card Punches 1-0 Check Read	digits 25-24, line 7, Vp digit 31, line 29, Vp digit 26, line 2, Vc	10 m.s.
Card Punches 1-0, Punch Row	digits 25-24, line 6, Vp digit 30, line 29, Vp digit 26, line 2, Vc	38 m.s.
Card Punches 1-0, End of Card	digits 25-24, line 5, Vp digit 29, line 29, Vp digit 26, line 2, Vc	
Teleprinters 15-8	digits 31-24, line 2, Vp digit 26, line 29, Vp digit 26, line 2, Vc	100 m.s. for full speed
Teleprinters 7-0	digits 31-24, line 1, Vp digit 25, line 29, Vp digit 26, line 2, Vc	100 m.s. for full speed
Clock, one second	digit 26, line 0, Vp digit 24, line 29, Vp digit 26, line 2, Vc	100 m.s.
Clock, tenth of a second	digit 25, line 0, Vp digit 24, line 29,Vp digit 26, line 2, Vc	100 m.s.
Instruction Counter	digit 24, line 0, Vp digit 24, line 29, Vp digit 26, line 2, Vc	-
Non-equivalence or Lock-out	digit 25, line 2, Vc	-
Drum Transfer Fail	digit 28, line 60, Vd digit 31, line 1, Vc digit 24, line 2, Vc	- -
Drum Cabinet Absent	digit 27, line 60, Vd digit 31, line 1, Vc digit 24, line 2, Vc	-
Drum Transfer Complete	digit 26, line 60, Vd digit 31, line 1, Vc digit 24, line 2, Vc	-

Cause of Interrupt	V-Store digits set	Critical Time or Information to be printed out
Magnetic Tape Deck Failure, Channels 7-0	digits 31-24, line 27, Vm digit 30, line 1, Vc digit 24, line 2, Vc	-
Exponent Overflow	digit 29, line 1, Vc digit 24, line 2, Vc	eo Programme Trapped or Monitored
Non-equivalence on magnetic drum or tape transfers	digit 28, line 1, Vc digit 24, line 2, Vc	-
Sacred Violation by Operand	digit 27, line 1, Vc digit 24, line 2, Vc	svo Programme Monitored
Sacred Violation by Instruction	digit 26, line 1, Vc digit 24, line 2, Vc	svi Programme Monitored
Division by non-standard or zero number (374, 376, 377 basic orders only)	digit 25, line 1, Vc digit 24, line 2, Vc	do Programme Trapped or Monitored
Unassigned Functions	digit 24, line 1, Vc digit 24, line 2, Vc	ilinst Programme Monitored.

12.2 Action on an Interrupt

If one or more interrupt flip-flops are set and interrupts are not inhibited then before a further instruction is started

1) the octal number 40040000 is put into B125 (40060000 if digit 27, line 3 of the Central Computer V-store is a one).

2) the I/ME flip-flop is set to I.

The effect is to switch to interrupt control and to obey the instruction in address 2048 of the fixed store.

Interrupts are inhibited when

(a) I/ME = I or
(b) the Inhibit Interrupts flip-flop is set (e.g. when a sequence of instructions in a program has to be obeyed without interruption).

An exception is if non-equivalence occurs when Interrupt control is being used. In this case control is immediately transferred to line 2048 of the fixed store and the routine entered to find the cause of the interrupt. This interrupt can only be caused by a machine fault and no record is kept of the control number at the time of the non-equivalence.

To assist in the Interrupt Routine one of the B-registers (B 123) performs in a special manner. This register is loaded in the normal way but its output is 8 times (i.e. a shift of 3 binary places) the characteristic of the logarithm to base 2 of the 8 least significant digits of the input i.e. the output is the position of the most significant one.

	INPUT								OUTPUT					
digits	23-8	7	6	5	4	3	2	1	0	23-7	6	5	4	3	2 - 0
	δ	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	δ	0	0	0	0	0	0	1	δ	0	0	0	0	1	0
	δ	0	0	0	0	0	1	δ	δ	0	0	0	1	0	0
	δ	0	0	0	0	1	δ	δ	δ	0	0	0	1	1	0
	δ	0	0	0	1	δ	δ	δ	δ	0	0	1	0	0	0
	δ	0	0	1	δ	δ	δ	δ	δ	0	0	1	0	1	0
	δ	0	1	δ	δ	δ	δ	δ	δ	0	0	1	1	0	0
	δ	1	δ	δ	δ	δ	δ	δ	δ	0	0	1	1	1	0
	δ	0	0	0	0	0	0	0	0	0	1	0	0	0	0

To identify the cause of an interrupt the method in the interrupt routine is as follows

1) transfer line 2 of the central computer V-store to B123
2) transfer control to one of eight programs (via a jump table) modified by B123.

This identifies the type of interrupt and also ensures that for simultaneous interrupts the one with the highest priority is dealt with first.

If the interrupt is a parity interrupt, line 0 of the central computer V-store is transferred to B123 and control transferred (again via a jump table and modified by B123) to an appropriate program.

If the interrupt is due to one of the peripheral "look at me" indicators being set, the relevant mechanism can be identified by one or two further "references" to B123. For a card reader or an I.B.M. magnetic tape interrupt

12.2 Continued

the cause of interrupt can be identified by one further "reference" to B123. For a magnetic tape block address interrupt the appropriate channel can be identified by a further use of B123 and the mechanism currently on that channel is known to the magnetic tape supervisor program. For all other peripheral equipments it is necessary to copy the appropriate line (31, 30 or 29) of "Type 14" of the peripheral equipment V-store to B123 and transfer control (modified by B123) to the corresponding program. This identifies the type of equipment and one further use of B123 identifies the equipment itself that caused the interrupt.

For a "non-equivalence or lock-out" interrupt the fixed store program must determine whether the interrupt is due to a non-equivalence of either the operand or instruction address or whether the interrupt is caused by the required block being locked out. To do this it first examines the "Operand non-equivalence or lock-out" digit in the Core Store V-store (line 34, digit 35). If this is set it is possible to find out from the page directory in the subsidiary store whether the required block is in the core store and if it is whether it is locked-out. If the Operand non-equivalence digit is not set the address of the required instruction can be determined from examination of the M/E digit and the contents of B126 or B127, as appropriate. The reason for the interrupt is then determined as before from the page directory.

If the fixed store routine finds that the interrupt is due to a block being locked-out it either enters the Engineers Tests or switches programmes. If the interrupt is due to the required block not being in the core store a drum transfer program is entered.

For the other interrupts line 1 of the Central Computer V-store is transferred to B123 and the appropriate programme is entered (e.g. for exponent overflow). The "Non-equivalence, tapes or drums" digit is set during a magnetic drum or magnetic tape transfer if non-equivalence is obtained either due to a page address register not being set correctly or a fault occurring. The appropriate transfer can be terminated by writing to the "Stop Command" digit for a drum transfer or the "End Transfer" digit for the appropriate channel for a tape transfer. The non-equivalence for this digit is only over the block digits (i.e. 22-12) of the address and does not include the lock-out digit. It is set independently of the Non-equivalence or Lock-out digit in line 2 of the Central Computer V-store.

The interrupts are dealt with in order of priority and after an interruption has been dealt with the flip-flop which led to the interrupt is reset (e.g. a card reader Look At Me). After the appropriate action for an interrupt has been taken, control is transferred to line 2048 of the fixed store and a further examination is made of the interrupt digits of line 2 of the Central Computer V-store. If one of these digits is set the appropriate routine is entered. If none of these digits is set the control number in either B126 or B127 is adjusted if necessary and control switched back to Main or Extracode i.e. the I/ME digit is reset to ME.

For most interrupts no adjustment of the number in the control being obeyed before the interrupt occurred is necessary on leaving the interrupt program. However for an interrupt due to non-equivalence or lock-out of the operand (digit 35, line 36 of the Core Store V-store set) control is advanced by either one or two before the interrupt program is entered and must be adjusted accordingly before a switch back to this control takes place. The adjustment required is given by digit 26 of line 3 of the Central Computer V-store (the +1/+2 digit).

12.2 Continued

This digit is normally reset to zero (+2) but it is set to one either (a) if an unscrambled code (Z-code) causes a non-equivalence or lock-out interrupt for its operand or (b) if another interrupt occurs whilst an instruction is being obeyed but before the non-equivalence or lock-out is detected.

The "Non-equivalence or Lock-out on Extracode Exit" digit (line 3, digit 28 of the Central Computer V-store) is set to one whenever Main Control is advanced by one and it is reset to zero on switching to Extracode control. If a Non-equivalence or Lock-out interrupt occurs when an Extracode exit instruction is obeyed both the Main and Extracode control numbers are advanced by one. Consequently the Non-equivalence interrupt routine examines digits 26 of line 3 and 24 of line 4 of the Central Computer V-store and if these are both zero (i.e. +1/+2 set as +2 and M/E set as E) it also examines digit 28 of line 3. If this latter digit is set then both Main and Extracode control numbers must be reduced by one before returning to the extracode exit instruction.

One use of the Inhibit Interrupt flip-flop is when control is being switched from E to I. The program to do this is

```
121,   100,   0,   0.1    )
                           ) Inhibit Interrupts
113,   100,   0,   3 * 6  )

121,   125,   0,    (1)     Set contents of B125

121,   100,   0,   0.2    )
                           ) Switch control to I
113,   100,   0,   3 * 6  )
```

If the Inhibit Interrupts flip-flop were not set an interrupt might occur immediately after B125 had been set. After carrying out this latter routine B125 would be left set from this routine and not as required by the program specifying the change of control.

Section 13 Layout of the V-store

13.1 Addresses of the V-store

A V-store address is identified by having digits 23 - 21 as 110 respectively. Digits 20 - 15 and digit 11 are spare and digits 14 - 12 identify the part of the V-store being referred to. Digits 10 - 3 give the address of the appropriate word within the relevant part of the V-store. As the full allocation of words is not needed in all the parts of the V-store the most significant of these digits are not used in some cases. Only the more significant half-words are used in the V-store and hence address digits 2,1 and 0 are always zero.

The allocation of digits 14 - 3 in a V-store address is given in the following table.

digit	14	13	12	11	10	9	8	7	6	5	4	3	
	0	0	0	0	0	0	0	0	0	δ	δ	δ	Central Computer
	0	0	1	0	0	0	δ	δ	δ	δ	δ	δ	Core Store
	0	1	0	0	0	0	δ	δ	δ	δ	δ	δ	Drum
	0	1	1	0	0	0	0	δ	δ	δ	δ	δ	Magnetic Tape
	1	0	0	0	δ	δ	δ	δ	δ	δ	δ	δ	Peripheral Equipments
	part of V-store			spare	word within the appropriate section								

The notation used in the following sections for reading from or writing to the digits in the V-store is

R where it is possible to Read only; writing has no effect and digits not so marked are always read as zero
W1 where it is possible to Write Ones only; reading gives zeros and writing zeros has no effect
W10 where it is possible to Write Ones and Zeros; reading always gives zeros
RW0 where it is possible to Read and where a digit is reset by Writing Zero to it
RW1 where it is possible to Read and also to Write Ones; writing zeros has no effect. A digit is reset to zero by writing a one to it.
RW10 where it is possible to Read and also to Write Ones and Zeros

13.2 Central Computer V-store

The first three lines are concerned with interrupts and are used to identify the source of an interruption.

line	digit			
0&6	31	RWO	Parity 1	Core store addressed by the machine
	30	RWO	Parity 2	Drum transfer. This digit is set if incorrect parity is detected (a) in the contents of the core store page involved in a write transfer (b) in the information on a drum sector for a read transfer.
	29	RWO	Parity 3	Magnetic Tape Transfer. This digit is set if incorrect parity is detected (a) in the contents of the core store page involved in a write transfer (b) in the information read from the tape co-ordinator Buffer Store to the Main Core Store page.
	28	RWO	Parity 4	Subsidiary store
	27	RWO	Parity 5	Fixed store
	26	RWO	Parity 6	Magnetic Tape Buffer
	25	RWO		Non-equivalence in Interrupt control. This digit is set if non-equivalence occurs between digits 22-12 of the required address and the corresponding digits of all the Page Address Registers due to either a machine or fixed store programme fault when on Interrupt Control. The setting of this digit also sets address 2048 of the fixed store in interrupt control and the routine for finding the cause of an interrupt is entered immediately. No record is kept of the previous interrupt control number.
1	31	R		Drums. The "OR" of digits 29, 28, 27 and 26 in line 60 and digit 27 in line 56 of the drum V-store
	30	R		Magnetic tape deck failure. The "OR" of line 19 of the Magnetic Tape V-store
	29	RWO		EO Accumulator exponent overflow
	28	RWO		Non-equivalence, tapes or drums.
	27	RWO		SVO Sacred violation by the operand. An illegal reference by the operand to one of the private stores.
	26	RWO		SVI Sacred violation by an instruction. An illegal attempt to obey an instruction in the private stores.
	25	RWO		DO Division by non-standard or zero number (set by basic functions 374, 376, 377 only).
	24	RWO		Unassigned Functions
2	31	R		Parities The "OR" of line 0
	30	R		PO Peripherals 0 (the card readers, I.B.M. tape)
	29	R		T Magnetic tape block markers. The "OR" of line 18 of the Magnetic Tape V Store.
	28	R		P1 Peripherals 1 (Graphical outputs, TR7 and N.E.P. tape)
	27	R		P2 Peripherals 2 (the Teletype punches, TR5's and Creed 3000 paper tape punches)
	26	R		P3 Peripherals 3 (the instruction counter, clock, tele-printers, Anelex printers, card punches and X-ray Diffractometer).
	25	RWO		Non-equivalence or Lock-out. The non-equivalence of all page address registers or a programme reference to a locked-out page of the main core store.
	24	R		the "OR" of line 1

13.2 Continued

line	digit		
3	28	R	Non-equivalence on Extracode exit (see Section 12.2)
	27	W10	Engineers Tape Reader. Selected by writing a one
	26	R	+1/+2 (1/0). On a non-equivalence or lock-out interrupt due to an operand not being available this digit indicates whether one or two has been added to control
	25	RW10	I/ME Control flip-flop (1 if I)
	24	RW10	$\bar{I}$ Inhibit interrupts (set to 1 to inhibit interrupts)
4	24	RW10	M/E Control flip-flop (1 if M)
6	29	RW10	12/13 Shift. "1" if 12 shift. Reset by every division order
	28	RW10	Qs. Sign of quotient in basic division orders.
	27	RW10	A0 (Fixed point) accumulator overflow
	26	RW10	Bt < 0) B test register
	25	RW10	Bt ≠ 0)
	24	RW10	Bc B-carry
7	31-24	R	8 handswitches
	27	W10	Hooter

13.3 Core Store V-Store

13.3.1 32-Page Coordinator

The layout of the Core Store Coordinator for the Manchester University Atlas is given below. The layout of the V-store for all other machines is given in the next section.

Lines		Digit		
0-31	W10	47	Page lock out)	Page address registers
	W10	46-36	Block address)	
32	R	47-32	"Use" digits of pages 15 to 0 respectively.	
33	R	47-32	"Use" digits of pages 31 to 16 respectively.	
34	R	47	Instruction non-equivalence or lock out	
	R	46-36	Block address on operand non-equivalence or lock out	
35	W10	47	Ignore all lock-out digits	
	R	46-37	Line address on operand non-equivalence or lock out (digits 11-2 respectively of the specified address).	

The digits in lines 32 and 33, also digits 46-36 in line 34 and digits 46-37 in line 35 are reset to zero automatically when the information is read (by program) from them.

Digit 47 of line 34 is automatically reset to one when line 34 is read.

Digit 47 of line 35 is unaltered when line 35 is read. It is always read as zero but the lock out digits are ignored (i.e. no lock out interrupts occur) if the last digit written to it was a one. It is reset by writing zero to it.

The "non-equivalence or lock out" block and line addresses are set when an interrupt occurs due to the required operand not being immediately available in the core store i.e. the required information block may be either not in the core store or it may be locked out. These digits are not set on an interrupt due to an instruction not being available.

The Instruction non-equivalence or lock out digit is set to zero (i.e. Operand) when a non-equivalence interrupt occurs due to the required operand not being available.

13.3.2. General Core Store V-Store

The layout of the Core Store coordinator for machines of up to 128 pages (other than the Manchester University Atlas) is given below.

	Lines		Digits	
(a)	0-31	W10	47 Page lock out 46-36 Block address	Page Address Registers
(b)	32-63			
(c)	64-95			
(d)	96-128			
(a)	128	R	47-32 Use Digits	Pages 15 - 0
	129			31 - 16
(b)	130			47 - 32
	131			63 - 48
(c)	132			79 - 64
	133			95 - 80
(d)	134			111 - 96
	135			127 -112
(a)	136	R	47 Instruction not equivalence 46-36 Block Address 46-37 Line Address	Set on not equivalence or lock out of operand digits
	137	W10	47 Ignore all lock out	

For 96 or less pages, lines (d) vacant

For 64 or less pages, lines (c) vacant also.

For only 32 pages, lines (b) vacant also.

The digits in lines 128 - 135, digits 46 - 36 in line 136 and digits 46 - 37 in line 137 are automatically reset to zero when the information is read by program from them.

Digit 47 of line 136 is reset to one when line 136 is read.

13.4 Drum v-store

(maximum of 8 Cabinets, each cabinet containing either one file drum or up to four fast drums, type MD5)

Lines		Digits	
0-31	R	29-27	θ- registers
	R	26	"1.5 - 2" digit
	(for drums 0-31 respectively)		
32	R	29-27	Blocks complete (cleared to zero when write to Start digit, digit 29 line 56)
36	RW10	29-27	Number of blocks requested.
40	RW10	29-27	Starting θ
44	RW10	28-26	Band on the appropriate drum
48	RW10	27-26	Drum (within a cabinet)
52	RW10	28-26	Cabinet
56	RW1	29	Read: Started (indicates a drum transfer is in progress) Write: Start (initiates a drum transfer)
	W1	28	Selection change
	RW1	27	Read: Drum Transfer Complete Look At Me Write: Read
	RW1	26	Write
60	RW1	29	Read: Drum Count Failure Look At Me (In the gap between sectors the count of words is tested; it should be a multiple of 512) Write: Stop
	R	28	Drum Cabinet Absent Look At Me (Drum cabinet non existent or unplugged)
	RW1	27	Read: Drum Band Isolated Look At Me. (Trying to write to a band whose isolation switch is on.) Write: Reset DTC Look At Me
	RW1	26	Read: Drum Request Ignored Look At Me (the core store has not accepted address from the drum in time) Write: Reset Drum Failure LAM's (ie.e. DCF, DCA, DBI and DRI)

The "OR" of line 60 and line 56 digit 27 provides the Drum Interrupt, D (digit 31 of line 1 of the Central Computer V-store).

DCA and DBI are set when appropriate after a one is written to the Start digit (digit 29 line 56) but a drum transfer is not initiated. When DCF and DRI occur, the drum transfer is automatically stopped. DTC cannot occur at the same time as a drum failure.

13.5 The Magnetic Tape V-store

Line	Digit		
0-6 * (000)	36-24	R	Present Block Address Register for Channels 0-6
7 * (007)	36-24	RW10	Present Block Address Register for Channel 7
8-15	41-24		Tape Command Registers
	41	RW1	Fast Speed
	40	W1	Normal Speed
	39	RW1	Reverse
	38	W1	Forward
	37	RW1	Start
	36	W1	Stop
	35	W1	Disengage Deck
	34	R	Buffer Parity Fault (on writing to tape).
	33	RW1	Recover Read
	32	W1	Normal Read
	31	RW1	Write: Read at next Block Address Read: Read Transfer
	30	W1	End Read at next Block Address
	29	RW1	Write
	28	W1	End Transfer
	27	R	Write Permit
	26	R	End of Tape
	25	R	Not 512 Word Transfer
	24	R	Check sum fail
16	39-24	R	Disengaged Flip-Flops for Decks 15-0
17	39-24	R	Disengaged Flip-Flops for Decks 31-16
18	31-24	RW1	Block Address Interrupt for Channels 7-0 Writing '1' resets the digit to '0'
19	31-24	RW1	Deck Failure Interrupt for Channels 7-0 Writing '1' resets the digit to '0'
20	36-24	W10	Select Deck and Channel
21	35-24		Tape Address Command Register for Channel 7 only
	35	R	Deck Modified
	34	RW1	Leading address indication
	33	RW1	Permit count
	32	W1	Do not permit count
	31	RW1	Write Reference Marker
	30	W1	Do not write Reference Marker
	29	RW1	Write '1's
	28	W1	Do not write '1's
	27	RW1	Address tape
	26	W1	Do not address tape
	25	RW1	Address Fault
	24	W1	Reset Address Fault

The "OR" of line 18 is Digit 29 of line 2 of the Central Computer V-store.
The "OR" of line 19 is Digit 30 of line 1 of the Central Computer V-store.
The tape V-store includes registers in the mechanisms. Some of these are flip-flops of the peripheral type, requiring long trigger pulses.
The generating of these pulses causes the Write Access time for the tape V-store to be 5 μsec.

22	25	RW1	Crisis Time Fault - Read Tape - Writing 1 resets to 0
	24	RW1	Crisis Time Fault - Write Tape - Writing 1 resets to 0

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13.6 Peripheral Equipment V-Store

13.6.1 V-Store Addresses

Each equipment has associated with it one or more lines of the V-store. Equipments of the same type are in consecutive lines (or groups of consecutive lines) and only the most significant half-words are used.

The peripheral equipment V-store addresses are:-

23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	0	0	0	0	0	0	1	0	0	0	δ	δ	δ	δ	ε	ε	ε	ε	0	0	0
V-store				Spare					Peripheral				s p a r e	Type			Number						

The "types" and the corresponding interrupt digits in line 2 of the Central Computer V-store are:

			Starting Address
Type 0	Card Readers	(P1)	*6004000
Type 1	Spare (London only: High Speed Data Link)	(P2)	*6004020
Type 2	TR7 Paper Tape Readers and N.E.P. Tape	(P2)	*6004040
Type 3	Graphical Outputs	(P2)	*6004060
Type 4	Anelex Printer	(P2)	*6004100
Type 5	I.B.M. Magnetic Tape	(P1)	*6004120
Type 6	Fast Paper Tape Punches	(P3)	*6004140
Type 7	TR5 Paper Tape Readers	(P3)	*6004160
Type 8	Teletype Punches	(P3)	*6004200
Type 9	Card Punches (and, Manchester only, X-ray Diffractometer)	(P4)	*6004220
Type 10	Spare (Manchester only: A.T. & E. On-Line Data Links)		*6004240
Type 11	Teleprinters	(P4)	*6004260
Type 12	Clock, Instruction Counter and date	(P4)	*6004300
Type 13	Spare		*6004320
Type 14	"Look at me's"		*6004340
Type 15	"Look at me's"		*6004360

13.6.2 V-Store Digits

Type 0. Card Readers (maximum 4) (*6004)

lines	digits		
0-3	47-36	R	Information (Rows +,-,0-9 respectively)
(Card readers number 0-3 respectively)	30	RW1	Read: Overdue Write: Reset Overdue
	29	W1	Do not Divert
	28	RW1	Read: Card Levels Write: Put Out End of Card Look At Me
	27	W1	Start
	26	RW1	Read: Disabled Write: Put Out Column Ready "Look At Me"
	25	RW1	Stopped/Stop
	24	RW1	Disengaged/Disengage
8-11	47-36	R	Check Information (Rows +,-,0-9 respectively)

Type 1.

lines	
1 9	London only: Imperial College High-Speed Data Link

Type 2a TR7 Paper Tape Readers (maximum 4) (*600404)

lines	digits		
0-3 (Tape Readers number 0-3 respectively)	36	R	Disabled
	35	R	Tape Broken
	34	R	Overdue
	33	R	5/7 switch ("1" if five channel; "0" if seven channel)
	32-26	R	Information. The location hole is between digits 28 and 29. Digits 31 and 32 are zero for five-channel tape.
	30	W1	Stop Rewind
	29	W1	Rewind
	28	W1	Reset Overdue
	27	W1	Start
	26	W1	Put out "Look at Me"
	25	RW1	Stopped/stop
	24	RW1	Disengaged/disengage

Type 2b N.E.P. Tape (*6004041 on Manchester University Atlas)

line	digits		
1	36	R	Mode of Operation. 1 if Writing;0 if Reading
	35-29	W1	Write: Information Read: Disabled
	34	R	Read: Overdue
	33	R	5/7 Channel. 1 if 5 Channel. 0 if 7 Channel.
	32-26	R	Read: Information
	28	W1	Write: Reset Overdue
	27	W1	Write: Start
	26	W1	Write: Put out Look At Me
	25	RW1	Stopped/Stop
	24	RW1	Disengaged/disengage

Type 3. Graphical Outputs (maximum 2) (*600406)

lines	digits		
0-1 (Graphical Outputs number 0-1 respectively)	27	RW1	Read: Camera Fault Write: Start
	26	RW1	Read: Brilliance Write: Put out Look At Me
	25	RW1	Stopped/Stop
	24	RW1	Disengaged/disengage
8-9	47-38	W1	x - co-ordinate
	35-26	W1	y - co-ordinate
	25	W1	Display
	24	W1	Dim

Type 4. Analex Printer (maximum 4) (*60041)

lines	digits		
0-3 (Analex Printers 0-3 respectively)	36	W1	Clear Core Store
	35	W1	End of Line
	34	W1	Information Strobe
	33-28	W1	Incormation
	27	RW1	Read: Disabled Write: Start
	26	RW1	Read: Paper Warning Write: Put out Look At Me's
	25	RW1	Stopped/Stop
	24	RW1	Disengaged/disengage

Type 5. I.B.M. Tape (*600412)

Line	digits		
0	24-26	RW1	No. of odd characters. N.B. 000 means 8 characters
	27-35		address of last word accessed in core store
	36	RW1	Read: DISENGAGED Write: READ
	37	RW1	Read: LONGITUDINAL PARITY Write: WRITE
	38	RW1	Read: LATERAL PARITY Write: BACKSPACE
	39	RW1	Read: MECHANICAL FAILURE Write: REWIND
	40	RW1	Read: TAPE INDICATOR (end of tape detected during write operations only) Write: REWIND UNLOAD
	41	RW1	Read: LOAD POINT (beginning of tape) Write: LONG GAP
	42	RW1	Read: LOW DENSITY Write: LOW DENSITY
	43	RW1	Read: BCD MODE Write: BCD MODE
	44	RW1	Read: REWINDING (implies disengaged) Write: RECOVER READ
	45	RW1	Read: FILE MARK READ Write: SKIP TO FILE MARK
	46	W	Write: EVEN PARITY
	47	RW1	Write: POLAM Read: INVERSE LAM (0 if LAM)

Line 1	digit		
	24-26	W	SELECT TAPE UNITS 1 - 6

Type 6. Creed 3000 Paper Tape Punch (maximum 4) (*600414)

lines	digits		
0-3 (Tape Punches 0-3 respectively)	35-29	W1	Information
	28	RW1	Read: Check Fail Write: Reset Check Fail
	27	RW1	Read: Disabled Write: Start
	26	RW1	Read: Tape Warning Write: Put out Look At Me
	25	RW1	Stopped/Stop
	24	RW1	Disengaged/Disengage

Type 7. TR5 Paper Tape Readers (maximum 16) (*600416 to *6004177)
(5 or 7 track tape)

lines	digits		
0-7 (Tape Readers number 0-7 respectively)	34	R	Overdue
	33	R	5/7 switch ("1" if five-channel; "0" if seven-channel)
	32-26	R	Information. The location hole is between digits 28 and 29. Digits 31 and 32 are zero for five-channel tape.
	28	W1	Reset Overdue
	27	W1	Start
	26	W1	Put out Look At Me
	25	RW1	Stopped/Stop
	24	RW1	Disengaged/Disengage

Type 7a TR5 Paper Tape Reader (5,7 05 8 track)

*6004164, one only, on London and N.I.R.N.S.
i.e. TR5 No. 4.

digits		
35	R	8/75 switch (1 if 8 track)
34	R	Overdue
33	R	5/7 Switch (1 if 5 track) if digit 35=0 Information (8th track) if digit 35=1
32-26	R	Information
28	W1	Reset Overdue
27	W1	Start
26	W1	Put out Look At Me
25	RW1	Read: Stopped Write: Stop
24	RW1	Read: Disengaged Write: Disengaged

Type 8. Teletype Punches (maximum 8) (*60042)

lines	digits		
0-7 (Teletype punches number 0-7 respectively)	35-29 (33-29 for five channel punches)	W1	Information. The location hole is punched between digits 31 and 32
	27	RW1	Read: Disabled Write: Start
	26	RW1	Read: Tape Warning Write: Put out Look At Me
	25	RW1	Stopped/Stop
	24	RW1	Disengaged/disengage

Type 9a I.C.T. Type 582 Card Punches (maximum 2) (*600422)

lines	digits		
0-1 (Card Punches 0-1 respectively)	47-40	RW10	Information. One digit of each of columns 8-1 respectively where column 1 is that first in the card punch.
	39	RW1	Read: Card Levels Write: Put out Brush Look At Me
	38	RW1	Read: Card Wreck Write: Reset Overdue
	37	R	Overdue
	29	W1	Do Not Offset
	28	W1	Put Out End of Card Look At Me
	27	W1	Start
	26	W1	Put Out Punch Look At Me
	25	RW1	Read: Stopped Write: Stop
	24	RW1	Read: Disengaged Write: Disengage
4-5	47-24	RW10	Information (see line 0). One digit of each of columns 32-9 respectively.
8-9	47-24	RW10	Information (see line 0). One digit of each of columns 56-33 respectively.
12-13	47-24	RW10	Information (see line 0). One digit of each of columns 80-57 respectively.

Type 9b The X-ray Diffractometer

Line 5. (*60042250)

Digit	Write	Digit	Read
24-43	Information	24-43	Information
44	Load Information (LIv)	44	Reflected Count Overflow
45	Start Count (SCv)	45	Check read
46	Set the Position (SPv)		

Line 9. (*60042310)

Digit	Write	Digit	Read
24	Disengege	24	Disengaged
25	2θ (Two-theta) (2θv)	25	2θ
26	W (omega) (Wv)	26	W
27	ø (PHI) (øv)	27	ø
28	X (CHI) (Xv)	28	X
29	Z-line (Z-v)	29	Clamp out of range
30	V-reset	30	Limit switch failure
31	Clamp registers (CRv)	31	References reached
32	Read selected register (RIv)	32	Test A
33	Put out position set L.A.M.	33	Test B
34	Put out count complete L.A.M.	34	Test C
35	Put out contingencies L.A.M.	35	Test D
36	Open shutter	36	Test E
37	Close shutter		
38	Drive W - circle (CWDRv)		
39	Drive 2θ - circle (2θDRv)		
40	Drive to references (DRv)		

Line 13. (*00642350)

Digit			
24	Test and isolate motors and nucleonics (TIMN)		
25	Reset test and isolate motors and nucleonics (RESET-TIMN)		
26	Test-count start	*	(TCS)
27	Test-count-stop	*	(TCst)
28	Test set-add	*	(TSA)
29	Test set-subtract	*	(TSS)
30	Test add ± 1	*	
31	Test fringes		(TFv)

The Z-line

Digit	Write	Digit	Read
24	Set window 1	24	Window 1 in
25	Reset window 1	25	Window 2 in
26	Set window 2	26	Window 3 in
27	Reset window 2	27	Window 4 in
28	Set window 3	28	Balanced filter 1 in
29	Reset window 3	29	Balanced filter 2 in
30	Set window 4	30	Attenuator 1 in
31	Reset window 4	31	Attenuator 1 in
32	Set balanced filter 1	32	Counting clock
33	Reset balanced filter 1	33	Motor speed 1
34	Set balanced filter 2		
35	Reset balanced filter 2		
36	Set attenuator 1		
37	Reset attenuator 1		
38	Set attenuator 2		
39	Reset attenuator 2		
40	Count clock		
41	Count X-Rays		
42	Set motor speed 1		
43	Set motor speed 2		

Type 10 (Manchester Only) A.T.&.E. On-Line Data Link

Even Numbers INPUT LINK

Line		V-store line
0 -	Spare	*6004240
2 -		*6004242
4 -		*6004244
6 -		*6004246
8 -		*6004250
10 -		*6004252
12 -		*6004254
14 -	Manchester C.O.S.T.	*6004256

Digits		
35	R	Line Break
34	R	Overdue
33	R	Error Monitor
32-26	R	Information (the location hole is between digits 28 and 29)
27	W1	Start
26	W1	Put Out Look At Me
25	RW1	Stopped/Stop
24	RW1	Disengaged/disengage

Odd Numbers OUTPUT LINK

Line		V-store line
1 -	Spare	*6004241
3 -		*6004243
5 -		*6004245
7 -		*6004247
9 -		*6004251
11 -		*6004253
133-		*6004255
15 -	Manchester C.O.S.T.	*6004257

Digits		
35-29	W1	Information (the location hole is between digits 31 and 32)
28	R	Line Break
27	RW1	Read: Backspace Write: Start
26	RW1	Read: Disengage Request Write: Put Out Look At Me
25	RW1	Stopped/Stop
24	RW1	Disengaged/disengage

Type 11. Creed 75 Teleprinters (maximum 4) (Printer Only) (*600426)

lines	digits		
0-3	35,34,32-29	W1	Information
(Teleprinters number 0-3 respectively)	27	RW1	Read: Disabled Write: Start
	26	RW1	Read: Paper Warning Write: Put Out Look At Me
	25	RW1	Stopped/Stop
	24	RW1	Disengaged/disengage

Type 12. Instruction Counter, Clock and Date

(a) Instruction counter (*60043)

line	digits		
0	46-36	RW10	Information
	27	W1	Start
	26	W1	Put Out Look At Me
	25	RW1	Stopped/Stop
	24	R1W1	Write Strobe (always read as a one)

(b) Clock (*6004301)

1	45-44	R	hours, tens
	43-40	R	hours, units
	38-36	R	minutes, tens
	35-32	R	minutes, units
	30-28	R	seconds, tens
	27-24	R	seconds, units
	27	W1	Start
	26	W1	Put out 1 sec Look At Me
	25	W1	Stop
	24	W1	Put out 1/10 sec Look At Me

(c) Date (*6004310)

8	45-44	R	Days, tens
	43-40	R	Days, units
	36	R	Month, tens
	35-32	R	Month, units
	31-28	R	Year, tens
	27-24	R	Year, units

Type 13.

Type 14. "Look at me's" (*600434)

line	digits		
0	24	R	Instruction counter
	25	R	Clock, every tenth of a second
	26	R	Clock, every second
1	24-27	R	Teleprinters 0-3
2	27	R	IBM Magnetic Tape, End of Operation
3	24-27	R	Anelex Printers 0-3, Overflow
	28-31	R	Anelex Printers 0-3, Print
6	24	R	Card Punch 0. End of Card
	25	R	Card Punch 1. End of Card or X-ray Diffractometer, Position set
	26	R	Card Punch 0. Punch
	27	R	Card Punch 1. Punch or X-ray Diffractometer, Count Complete
	28	R	Card Punch 0. Brush
	29	R	Card Punch 1. Brush or X-ray Diffractometer, Contingencies
8	24-31	R	Teletype punches 0-7
9	24-30	R	Spare
	31	R	(Manchester only) C.O.S.T. Output Link
11	24-31	R	TR5 paper tape readers 0-7
12	24-30	R	Spare
	31	R	(Manchester only) C.O.S.T. Input Link
14	24-27	R	Creed 3000 paper tape punches 0-3

Type 15. (*600436)

2	24-25	R	Graphical outputs 0-1
4	24-27	R	TR7 paper tape readers 0-3
	25	R	N.E.P. tape (Manchester University Atlas)
6	25	R	(London only) Imperial College High Speed Data Link
7	24-27	R	Card Readers 0-3, End of Card
8	24-27	R	Card Readers 0-3, Column Read

The "or" of line 8 is the digit P0 of the central computer V-store.

13	24	R	The "or" of line 0, type 14
	25	R	The "or" of line 1, type 14
	26	R	The "or" of line 2, type 14
	27	R	The "or" of line 3, type 14
	30	R	The "or" of line 6, type 14

The "or" of line 13 is the digit P3 of the central computer V-store

14	24	R	The "or" of line 8, type 14
	25	R	The "or" of line 9, type 14
	27	R	The "or" of line 11, type 14
	28	R	The "or" of line 12, type 14
	30	R	The "or" of line 14, type 14

The "or" of line 14 is the digit P2 of the central computer V-store.

15	26	R	The "or" of line 2, type 15
	28	R	The "or" of line 4, type 15
	30	R	The "or" of line 6, type 15
	31	R	The "or" of line 7, type 15

The "or" of line 15 is the digit P1 of the central computer V-store.